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CIS

RESEARCH AND DEVELOPMENT IN THE UNITED STATES: THE ROLE OF THE PUBLIC AND PRIVATE SECTORS

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY, NUCLEAR PROLIFERATION, AND
GOVERNMENT PROCESSES

OF THE

COMMITTEE ON
GOVERNMENTAL AFFAIRS
UNITED STATES SENATE

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RESEARCH AND DEVELOPMENT IN THE UNITED STATES: THE ROLE OF THE PUBLIC AND PRIVATE SECTORS

TUESDAY, MARCH 9, 1982

U.S. SENATE,
SUBCOMMITTEE ON ENERGY, NUCLEAR
PROLIFERATION, AND GOVERNMENT PROCESSES,
COMMITTEE ON GOVERNMENTAL AFFAIRS,
Washington, D.C.

The subcommittee met, at 9:35 a.m., in room 3302, Dirksen Senate Office Building, Hon. Charles H. Percy (chairman of the subcommittee) presiding.

Present: Senators Percy, Glenn, and Levin.

OPENING STATEMENT OF SENATOR PERCY

Senator PERCY. Good morning to all of you. This meeting of the Subcommittee on Energy, Nuclear Proliferation and Government Processes of the Governmental Affairs Committee is called to order.

This hearing is to examine what I, and I know Senator Glenn, believe to be one of the most important of all Government activities: research and development. Particularly, we will examine the role of the public and private sectors in funding the activities necessary to keep the United States on the leading edge of technology. Frankly, I am worried that we are not doing enough in research and development. Even though this year's budget shows an overall increase for R. & D.—with the lion's share in defense—I am concerned that the trials the American economy will face in this decade and beyond will require a level of ingenuity and innovation far beyond that of the past. We will have an opportunity for several hours today to talk directly with the President on Capitol Hill about these problems and their challenges and I imagine in those meetings we will hear some of the diversity of views that we all have on this particular subject.

The key to the greatness of the United States as a nation is its productivity and economic strength. Our Armed Forces, our great political institutions, and our efforts for stability and peace throughout the world all rest on the bedrock of the American economy. Without the engine of American industry running smoothly and efficiently at home, the United States could soon be reduced to a second-rate power.

I think there is no question that the foreign policy of this country, and the credibility of that whole policy, depends upon a strong national defense and you simply cannot, as we are finding out today, afford a strong national defense if you have a weak economy underneath it. So I think we were right to spend most of last year trying to build the base for a strong economy. But the economic recovery has not taken place. Our interest costs, the lack of equity financing, and the depressing effect of that financing route, has resulted in the economy simply not responding to what our hopes and our expectations were. But, what we face now is the question of where do we cut back? And I know it always has been possible for industry to cut back on R. & D. If you don't care about what the future of industry is going to be, you can do that. This is like maintenance, you can always temporarily cut back on maintenance and let the plant cut down, but eventually that is going to catch up with you. The question is simply, do you take a short-range view or do you take a long-range view?

The private sector is and will properly remain the primary source of research and development in the United States. And the private sector is also the most appropriate place for R. & D. to take place. Who could know better what research is needed for industrial purposes than those in industry who will ultimately make use of any new developments? Yet, there are areas that industry will not support—either because the payoff is too far in the future or the benefits of such a broad nature that, while useful for the society, they do not deliver any special advantage to whoever funded the research. This is the area where Government must step in.

I appreciate that the administration is trying to improve the climate for private sector research and development activity by reviving the economy and eliminating the disincentives to capital investment. Yet, I feel we also need Government support of some areas that are of particular national interest. I will single out energy as an important—but by no means the only—example. This oil glut we enjoy today is only the calm in the eye of a storm. It is a plain and obvious fact that the world must make the transition from an economy based on oil to the more efficient use of alternative fuels. We have a choice: We can either continue with business as usual and make the transition when conditions dictate, or we can prepare now by developing the appropriate technologies to smooth our way. Anything we can do to soften the blow to our economy of making this transition is a wise and prudent investment in the future. To wait and do nothing is simply penny-wise and pound-foolish.

Energy conservation research is an important example of an area that is neither high risk, long-term, nor basic research, yet is still appropriate for Government support. Even if we do improve the current economic climate, it is unclear if the private sector will invest adequately in several areas of conservation research. The building industry, which offers many opportunities to save energy, is highly fragmented, with little ability to pull together capital for R. & D. investments. Furthermore, many of the benefits of research, such as new building techniques, are not patentable. With these limitations on private investments, and given the clear national benefit from energy improvements, it seems to me that the Government should continue to fund this sort of R. & D. Yet, these programs are being cut. If the United States is to meet the challenges of the next decades, we must increase our research and development efforts. The alternative to more innovation and productivity is a continually faltering economy and the decline of America which that ultimately must mean. This alternative is simply not acceptable.

Senator Levin, we are very happy to have you. Do you have any opening comments?

OPENING STATEMENT OF SENATOR LEVIN

Senator LEVIN. Some very brief comments, Mr. Chairman.

First of all, I want to commend you and Senator Glenn for your initiative in calling for these hearings. I am totally supportive of what you are doing and share your concerns. What we are doing here in the energy budget—the R. & D. budget is the particular focus this morning—I believe will be looked back upon as perhaps the greatest mistake of the early 1980's. With all the problems over the current economic policy of this administration, I believe that the cuts in energy, including energy R. & D., rank at the top of the list of mistakes that are being made and history is going to show that in the early 1980's this Congress went along with major cuts in energy programs that were designed to give us some energy independence.

A few years ago energy independence is all we heard. People were waiting in line for gasoline and all we heard was when are we going to have alternative fuels? Some Representatives have been in this Congress for 35 and 40 years talking about alternatives to imported oil. Finally we did something about it a few years ago but now we are seeing that effort dismantled and the reduction in the R. & D. on energy is just really a symbol of that dismantlement of the overall energy programs.

The solar energy program is being reduced in this budget by 72 percent on R. & D. The energy conservation R. & D. has an 88-percent proposed reduction. Fossil energy R. & D. is proposed to have a 74-percent reduction, and so forth.

So, we are going to be spending 10 times more in the next 5 years on rapid deployment force to protect the oil fields in the Persian Gulf than we are going to be spending on efforts which could reduce our reliance on that very same oil. I think these energy cuts are a tragedy for our country, for our efforts to fight inflation, for our efforts to achieve foreign policy independence, to achieve a foreign policy which can be based on American self-interest rather than being restricted to the dictates of states holding all the energy cards.

And unless we continue very strongly down the road toward energy independence, in other words, unless we restore energy funding, including R. & D., I think the energy cuts of the early 1980's will be viewed as one of the tragic episodes in American history when efforts made to have energy independence were forgotten, were dismantled, and were abandoned.

Mr. Chairman, while I am not able to stay for very long, I just wanted to be here to indicate my support for your efforts to promote energy R. & D. I think your leadership in this area is absolutely critical if we are going to turn away from this new policy, which is 180 degrees away from the direction in which we should be heading.

Senator PERCY. Thank you very much, Senator Levin. We appreciate your being here, even if it is for only a short period.

Senator Glenn will be coming along shortly to take over the Chair. The Foreign Minister of West Germany is coming in to see me downstairs at 10:15, so I will be only here for part of the period.

We would like to welcome all of our witnesses. Our first witness is Dr. Nelson Douglas Pewitt, Assistant Director for General Sciences. Dr. Pewitt is representing the President's science adviser, Dr. George Keyworth.

Your full statement, Dr. Pewitt, will be incorporated in the record and we would like to have you summarize it in any way you see fit.

TESTIMONY OF NELSON DOUGLAS PEWITT, ASSISTANT DIRECTOR FOR GENERAL SCIENCES, OFFICE OF SCIENCE AND TECHNOLOGY POLICY

Mr. PEWITT. Thank you, Senator. We welcome the opportunity to set forth the administration's science and technology policy to the committee this morning. Rather than read the statement, I will present a brief summary of that policy and respond to questions if there are any.

As is evident by Dr. Keyworth's statement, and unlike previous administrations, the Reagan administration has early on set forth the clear and definite science and technology policy. That policy has been stated, restated repeatedly but more importantly, rather than just being a stringing together of words, the President's budget that he transmitted to the Congress in early February is concrete evidence of the commitment of the Reagan administration to that policy which sets very high value on the research and development activities of the Government.

I will highlight briefly, just touching on the main points of that policy, and then go on to address how we have implemented it.

First of all, the policy reflects the fact that compared with any other nation, the U.S. science and technology enterprise is strong and healthy. By any measurement of S. & T. support, the field is healthy. I won't go through indications of all of those this morning, they are in the statement.

Further, the policy reflects the fact that indicators external to the field of science, such as annual growth rate or percent of GNP is simply not a substitute for science policy.

Further, the United States cannot dominate all areas of science as it did in the period immediately following World War II. The success of our social values has built up other free-world democracies that compete successfully with us in many areas.

Our policy requires that priorities be established for deciding which activities we should support. We believe that the S. & T. community should participate in the process of making those decisions. To that end, Dr. Keyworth has recently established the White House Science Council. He is not here because he is meeting with the Science Council for the first time today. I am due to go and address that body after we leave here.

This Council is the first broadly based, wide-ranging scientific advisory body in the executive offices in almost 10 years. We think that the U.S. science and technology enterprise will benefit because of the existence of this body.

Another key point that we wish to make is the need to establish clear limitations on the Federal role in research and development. As long as the threat of Federal intervention is present, private initiatives are inhibited. Therefore, by establishing bounds on the Federal Government's role, we allow for greater private sector activity.

Our policy reflects the fact that in our view there are only two areas where the Federal Government should support a direct Federal role in research and development. The first of those areas are where the

Federal Government is itself the principal consumer of the results of R. & D. This mainly includes research and development for national defense and space technology and in regulation.

The second area appropriate for Federal support is R. & D. in the national interest, but which support by the private sector is precluded because the benefits of that activity are not capturable by a private sector investor.

Thus, our policy reflects strong support of basic research which, by its very nature, is too long-term and uncertain to be adequately supported by any but the Federal Government. On the other hand, in the civilian sector we have reduced significantly the applied research and demonstration activities that were previously supported.

We believe that the 1983 budget fully reflects the high priority the administration places on R. & D., a priority that reflects the understanding that the future economic well-being of the Nation, the health of our citizens and the security of our society depends on investments in R. & D. made today.

If R. & D. were a Federal budget function, it would represent the budget function with a larger growth over previous years than any other save national defense and interest on debt. Total R. & D. proposed for 1983 is up 11 percent over 1982.

Essentially all of that increase is for the defense sector but the civilian sector, while not experiencing overall growth, reflects our science and technology policy. Basic research is up by almost half a billion over 1982 or about 9 percent, while applied research and development in civilian agencies is actually below 1981 and 1982.

I hope that this brief statement is adequate. I will be happy to respond to questions.

Senator PERCY. Mr. Pewitt, we thank you very much indeed.

As I mentioned, Senator Glenn will be chairing these hearings when I leave to go downstairs to meet with the Vice Chancellor of West Germany, Hans-Dietrich Genscher.

I am very much interested in the fact—and I am going to discuss with him—that Germany has a cabinet-level ministry of research and technology.

Are you familiar with the way they operate over there? And, Dr. Pewitt, in your judgment, does having a cabinet-level ministry for science and technology, has that in any way had a major impact on productivity improvement and research in West Germany?

Mr. PEWITT. Well, clearly, the proposal for a cabinet-level science agency has been discussed for many years, and we are all familiar with most of the arguments for that.

It is our view that science and technology is not an end in itself, it supports other objectives of the Federal Government. The Science Adviser's Office does act to coordinate in the sense that it is appropriate for White House offices to coordinate and not manage other agency programs.

I think the key to this is, what works in Germany is not necessarily what woud work in our society. I can't imagine an agency whose objective is simply R. & D. being more effective than an agency that uses R. & D. to achieve other social goals, to be perfectly honest, in this society.

Senator PERCY. I would like to, without objection, insert in the record at this point an article by Dr. Ernest Ambler, Director of the

National Bureau of Standards, that he wrote for "Science" magazine, entitled "Cooperation in R. & D.: Whose Responsibility?"
[The article follows:]

[From Science magazine, Mar. 5, 1982]

Cooperation in R & D: Whose Responsibility?

Spurred by competitive and financial pressures, U.S. research laboratories in universities, industry, and government are searching for collaborative agreements to improve their performance. Many successful arrangements are being expanded and new ideas put forward. The National Bureau of Standards (NBS) has had considerable experience in cooperative research arrangements, and some thoughts based on our experience may be useful to others.

While some U.S. institutions are finding it possible to agree on long-term and comprehensive multimillion-dollar research ventures, we have found that cooperative efforts need not be long-term nor restricted to "big ticket" items. The big national research facilities must be shared, as we share our research reactor, synchrotron radiation source, and other facilities, but these need not be the models for all cooperative ventures. Our Research Associate Program has fostered a variety of useful cooperative research programs, many of which require little in the way of unique facilities and are narrow in scope. Each agreement has been tailored to fit the work at hand and the capabilities and goals of the participant.

Over the past decade. NBS initiated a series of research projects to improve our knowledge of the properties of liquefied natural gas (LNG) mixtures, containment materials, and measuring techniques. About half the work was funded by relatively small-scale cooperative programs with industry, particularly under the aegis of the American Gas Association. At one point we put together a 19-member consortium of natural gas users, importers, and utilities for a single project to develop a good equation of state for LNG. One of the most successful projects, backed by NBS, the American Gas Association, the Maritime Administration, and the American Bureau of Shipping, was simply to produce a well-documented, easy-to-use handbook of data for LNG users. Typically, it took 9 to 18 months to make the arrangements for a project in the LNG program. Likewise, we recently announced a major cooperative program with the American Society for Metals to collect evaluated alloy phase diagram data and make the data available through a computerized information system.

These are only two examples of the variety of our joint research ventures. About 100 industrial research associates and 40 postdoctoral fellows are working today at NBS. More than 325 professors and student are stationed in NBS laboratories each year under various guest worker arrangements. We have education agreements with 100 universities and colleges and joint research programs with the Electric Power Research Institute. the Gas Research Institute. the American Dental Association, the American Society for Testing and Materials, and others.

In carrying out cooperative research programs, one must be persistent, attentive to detail, and involve both the technical staff and managers in the initial detailed formulations and the later critiques of progress. In all out agreements there has been no substitute for the involvement of bench scientists and engineers. Laboratories wishing to collaborate in research should seek the advise of all potential participants, whether they are in industry, universities, or government. At NBS all research managers are encouraged and expected to make such interaction a way of life. That concern is manifested by daily contact with university and industry peers and users and by a variety of formal evaluation panels involving scientists ane engineers selected by the National Academy of Sciences and the National Academy of Engineering. This kind of regular interaction fosters an environment that is receptive to cooperative research.

The pluralistic nature of American society presents a real variety of opportunities for cooperation, and these opportunities should be imaginatively explored. It is up to managers and researchers to be ambitious and innovative in their planning for cooperative research and to have the will to work out seemingly small but nevertheless crucial details of mutual understanding.—Ernest Ambler, *Director, National Bureau of Standards, Washington, D.C. 20234.*

Senator Percy. He proposes here greater collaboration between universities, industry, and Government in R. & D. because this would not only save the Government money, but would also get better results by bringing members of the U.S. research communities together in various ventures.

I will soon be holding hearings on what the role of universities can be in the Middle West, cooperating together in the field of energy alone where I think we can make some tremendous strides. We do this work at Argonne Laboratory and at the Fermi Laboratory.

What, in your judgment, should be the role of private institutions and private laboratories, that may be partially funded by Government but work closely and collaborate with greater educational institutions in this country?

Is there a strong enough role being developed for them? What is the potential for expanding and strengthening it?

Mr. PEWITT. If I might preface my comment. There is much discussion about strengthening and changing the relationships that exist between the Federal Government, universities, and the private sector, especially much enthusiasm for efforts aimed at Federal Government being facilitators of university-industry collaboration. I have personal reservations about moving in that area too precipitously basically because of the mistrust that exists between institutions in this country.

I point out to you Admiral Inman's comment to the AAAS a few weeks ago where basically, in an attempt to indicate that people should not bring gasoline to a bonfire, there was a great overreaction to what he said, and I think it basically came about from mistrust of the Federal Government. Given the level of apprehension in academia, I think to embark on something that would change traditional relationships might be hazardous.

With regard to the role of the national laboratories, this is a major concern of our office. These laboratories represent a great wealth of individual and collective expertise and talent. We spent somewhere between 30 and 40 percent of the 40-some-odd-billion dollars that the Federal Government invests in R. & D. each year in these Federal laboratories. We are concerned that that effort be made as effective as possible. We are today impaneling a group under the White House Science Council which, if he accepts, will be chaired by David Packard, to look into Federal laboratories. The objective of that view is to look into defining clearly the role of the Federal laboratories in the performance of Federal R. & D., to look at ways to make the laboratory effort more effective. We are especially interested in looking at incentives within the laboratory to increase the coupling between the laboratory scientists and the private sector. This is not a study to put off addressing the problem. You would not get David Packard to engage in such an exercise, I think you know that.

Senator PERCY. I think we have no disagreement on the fact that first of all, new ideas and new approaches, as Dr. Ambler pointed out in his article, are needed. From your long experience in the scientific community, you agree that our national laboratories are among great assets in R. & D. areas.

I am worried that the cuts the administration has made in R. & D. have fallen disproportionately on some labs over others. This threatens the critical mass of scientific talent we have developed in our laboratories over the years. At Argonne National Lab, several programs have been literally wiped out and the talented scientists who ran them are leaving the labs. You have a real morale problem when you threaten cuts of this kind.

What is the administration doing to insure that the cuts we have made are felt by all of the labs more evenly? If we are all going to take cutbacks, what can we do so that they do not fall too severely on any one laboratory? Have you given any thought to transferring some of the nonmilitary research programs from the weapons labs to the large civilian labs that would be capable of carrying them out?

Mr. **Pewitt**. To the limit that our office directly intervenes—we are a policy office, we are not in the business of assigning work to particular laboratories; those are prerogatives that are very jealously guarded by each agency in Government. We have addressed the concern. We all are aware of what is happening within the laboratories. The reductions are primarily the result, as we understand them, of withdrawal from certain areas of research. We think that the laboratories are facing a time of difficulty, mainly brought on by the Federal Government not being good managers of its laboratories and being careful about placement of work in laboratories in the past.

And we have worked in a number of instances to alleviate particular concerns. The fact of the matter is, the overall R. & D. budget in energy is going down, the national laboratories of the Energy Department are in fact the major recipients of those funds and it is just mathematically impossible to prevent reduction. The transfer of defense work into nondefense laboratories is an especially difficult area because of the classification and the necessity to guard critical national security information.

Senator **Percy**. One last question to you.

The Energy Research Advisory Board of the Department of Energy recently concluded an analysis of Federal energy R. & D. priorities in which they said that on an overall basis within the DOE, R. & D. funding for energy conservation and end-use technology is underfunded, particularly when compared with funding levels for applied technology.

I point out in particular one area that many of us have been concerened about. Better than 170 Members of Congress are members of the Alliance to Save Energy, 5 or 6 Cabinet officers are advisers to that private sector group emphasizing more efficient use of energy rather than just new sources. The largest source of new energy available to us is conservation. It still is and it is a lasting thing no matter what form of energy you use. Conservation will help give you a very high return in investment. And the problem is, as I pointed out in my opening statement, conservation in the building industry is a very difficult thing for that industry to do.

Do you feel that balance is needed between the R. & D. budget for, say, nuclear research for which you propose in fiscal 1983 well over $1 billion, and our support for other energy technologies, such as conservation, which has an R. & D. budget in fiscal 1983 of only $17 million. The return on investment, by any calculation, is far higher in conservation and will have a permanent and lasting effect on the economy.

Why are we putting such a low level of funding there? I think we cut the budget 93 percent in conservation in favor of an increase of $800 million in nuclear. I am for nuclear, but I think that is a disproportionate amount of our R. & D. funds.

Mr. **Pewitt**. In fact, if my memory serves me correctly, the nuclear budget is down this year also from prior-year levels. It is still very significant because going back to our S. & T. policy, we don't see that a private sector investor in the nuclear area, because of the heavily regulated nature of the nuclear industry, could possibly capture the benefits of his investment. Investments mainly are required to overcome the regulatory concerns of the Federal Government. However, the return on investment argument, while true for energy conservation, argues that the Federal Government need not directly intervene with R. & D., that those investments will be made by the private sector. Federal funding of those activities will in fact drive out private sector initiative. That is the position of the administration, sir.

Senator **Percy**. I will argue with that philosophy, particularly when you have to have federally owned facilities, all public housing, where is the private sector initiative for that? Government is paying for the energy. It costs the Government money and yet the Government is not making the investment in conservation which will save the Government money. In a period of 2 or 3 years, the whole investment would be returned. Where is the private sector initiative involved there? There isn't any.

Mr. **Pewitt**. It is a question whether that is an appropriate decision to be made in the energy budget or whether that is one for the Health and Human Services people on how they invest their dollars, sir.

Senator **Percy**. I see the private sector moving rapidly, but I know so many of the areas where there just are not the built-in incentives.

Senator Glenn?

Senator **Glenn**. Thank you, Mr. Chairman. I was at another hearing when this opened and I was not able to be here and get my statement in.

Senator **Percy**. Why don't you give it now.

OPENING STATEMENT OF SENATOR GLENN

Senator **Glenn**. To summarize, last Thursday I inserted into the Congressional Record a rather lengthy statement entitled, "The Research and Development Crisis in America," copies of which are available this morning at the press table. I would like to ask consent to have that entered in the record as my opening statement.

Senator **Percy**. It will be incorporated in full in the record.

[The statement follows:]

Opening Statement of Senator Glenn

THE RESEARCH AND DEVELOPMENT CRISIS IN AMERICA

Mr. President, on March 9, 1982, the Subcommittee on Energy, Nuclear Proliferation, and Government Processes, of which Senator Percy is the chairman and I am the ranking minority member, will hold a hearing on "Research and Development: The Role of the Public and Private Sectors."

This hearing occurs at a time when it is increasingly important that public policymakers listen more carefully to what the scientific and technical community is saying about our competitive position with regard to R. & D. and industrial innovation.

We are witnessing today a wholesale retreat in the Federal role in civilian research and development in the United States. This retreat manifests itself in the shrinking amount of research support available to our universities, our private nonprofit research laboratories, and our national multiprogram laboratories.

It is as if we had decided that inquiry into the unknown is irrelevant to the removal of hunger, disease, and poverty from the world. Indeed just the opposite is true. Research has given us knowledge, knowledge has given us technology, and technology has revolutionized and is continuing to revolutionize the world. Consider that within a single lifetime, agriculture, the original basis of civilization, has lost its dominance in nation after nation. Today, in a dozen major countries, agriculture employs fewer than 15 percent of the economically active population. In the United States the figure is below 6 percent and is still shrinking, while agricultural productivity expands.

The benefits of technology

The symbols of technology are no longer just images of smoky steel plants or the clanking noises of an automobile assembly line. Rather the symbols of technology today include the relative silence and clean surroundings of the advanced technological processes involving space technology, electronics, and gene-splicing.

This ongoing technological revolution is not a historical anomaly. Just as our first human ancestors were driven to satisfy their curiosity about what lay beyond that next hill or valley, just as Columbus, Vespucci, and Cabot were driven to venture beyond the horizon, mankind is driven by an insatiable curiosity to explore the unknown. Our job must be to nurture the inquisitive and inventive mind, not stifle it. When we do nurture it the results may not be predictable, but the benefits can be incalculable.

Let us look at what has happened in the field of transportation over the past 100 years. First, recall that it took the human race millions of years to get to the point where man could travel at a speed of 100 miles per hour. That was in the 1880's. It took less than 60 years thereafter to quadruple the limit so that by 1938 airborne man was cracking the 400 mph line; in another 20 years the limit was doubled again; by the 1960's rocket planes approached speeds of 4,000 mph; and men in space capsules were circling the Earth at 18,000 mph. And even those who had the vision to be able to imagine such machines could not foresee all the benefits that would arise from their development. The spinoffs from the American space program, which includes the development of the field of microelectronics and the creation of powerful, portable, and low-cost computers, have led to a revolution in communications that will change the way we live and work from now on.

We are living today at a time of austerity. We are looking toward rigorous cost accounting in the justification of the expenditure of public moneys and that is not bad. But research is not amenable to the rigors of cost accounting. We may start off looking for one thing and find another. Sir Alexander Fleming, through an accidental discovery in 1929 that green mold slowed the growth and reproduction of bacteria, began the research that ended with the discovery of penicillin and the development of antibiotics. And Michael Faraday's experiments, that ended with the principle of the discovery of electromagnetism and the dynamo, set the stage for the development of new industries that all electrical engineers in particular, are familiar with. There is, in fact, a story about a famous exchange between Benjamin Disraeli and Michael Faraday regarding the invention of the dynamo. After Disraeli had inspected this earliest of generators he pointedly asked Faraday, "What good is this?" To which Faraday replied, "What good is a baby, Mr. Disraeli?" The point of that story is that one cannot judge the potential of a new discovery or of a new idea any more than one can judge the potential of a baby.

Our prosperity, our national security, our industrial strength have come about because we were willing to invest in research into the unknown and that willingness had paid handsome dividends. Let me cite a few examples.

In 1843 the U.S. Congress actively supported the development of the first practical application of electric energy with a grant of $30,000 to Samuel F. B. Morse to construct a telegraph line from Baltimore to Washington. Within 20 years no developed area in the United States was without telegraphic service and submarine cables were in regular operation under the Atlantic Ocean. In some sense, that was the beginning of the communications revolution that we are experiencing today.

In 1956 John Bardeen, William Shockley, and Walter Brattain shared the Nobel Prize for physics for their invention of the transistor. Subsequent Government policies on military procurement had a major effect on the development of the semiconductor industry thereafter, an industry which has become a mainstay of the U.S. economy.

In 1964 Charles Townes became a co-winner of the Nobel Prize for his research on the maser and laser. Today laser technology is used in a variety of activities ranging from brain surgery to otical scanners in suppermarkets.

Norman Borlaug won the Nobel Peace Prize in 1970 for his work on the development of high-yield grains. That research was not only used in this country, but was exported abroad where it provided the basis for the Green Revolution that fed a hungry world.

The list could go on and on, but the point is obvious. Research, and the technology we develop to exploit the fruits of that research, has made America the wealthiest, most powerful, and most productive Nation on Earth. R. & D. supported by both Government and private sources has transformed the United States into the dominant technological force in the world. It is the key to our productivity and to our ability to compete successfully in a highly competitive world market. Let us, therefore, examine what has been happening with respect to productivity in the United States and investment in R. & D.

U.S. slippage

Between 1961 and 1978 the annual productivity gain in manufacturing averaged 3 percent in the United States. This should be compared to an average gain of 9 percent in Japan, and 5 percent in Germany. Moreover, total U.S. private sector productivity has actually declined in recent years. That decline in productivity has cost us 2 million jobs since 1970. That fact makes me extremely concerned, especially with unemployment hovering at the 9-percent mark in this country today, but we cannot sit around wringing our hands. The Japanese are presently outproducing us in a number of areas.

We are being challenged as we never have been before. But let me tell you something. I welcome the challenge because given the proper tools, Americans can still outwork, outproduce, outinnovate, and outcompete anyone on the face of this planet. But if we are going to do it, we are going to have to turn around some worrisome trends that are occurring in the United States today—trends that indicate lagging capital investment, shortsighted management, lagging human resources, and most important of all, slippage in our commitment to maintain and extend the amount of research and development necessary to stay ahead in the technological race.

In capital investment we were first in the world in 1963. By 1975 we had slipped to sixth place on a per capita basis. Europeans are increasing their per capita investment in industrial plant and equipment at a rate which is double ours and the Japanese are doing so at a rate which is five times ours. We need to encourage savings and we are not going to do it by voodoo economics.

We have to educate our corporate managers to look beyond the planning horizon of 3 or 4 years. The economist Edwin Mansfield has shown that there is a direct relation between the amount of long-term basic research carried out by an industry or firm and its rate of productivity increase, all other things being constant. The short-term, bottom line mentality must be refocused toward the future. Short-term advantages can evaporate almost overnight and can have a devastating impact on our national security.

Let me give you an example. A recent Rand report discusses the difficulties the Soviets had until the early 1970's in trying to develop equipment for grinding precision miniature ball bearings which are important in current missile guidance systems. Within less than a decade, the Soviets are now claiming to have developed high precision machine tools capable of turning out miniature ball bearings with tolerances of two ten-thousands of 1 millimeter. These are closer tolerances, they claim, than Western equipment allows.

The conclusion is obvious. If we sit back and try to rest on the technological laurels we have, we will find the leaves of our laurels plucked away one by one. Unfortunately, when one sees what we have been doing with respect to human resources and investments in R. & D. over the past 10 or 15 years, it appears that we have, indeed, been sitting down on the job. And, I might add that if the Reagan administration's philosophy and budget continue to be accepted, we will go rapidly from a position of sitting down to a position of lying prostrate before the world.

Over the past 15 years the proportion of America's GNP invested in research and development has steadily declined—dropping more than 20 percent since 1965. During that same period and by that same measure, the Soviet Union's R. & D. investment has climbed by 21 percent, Japan's has risen by 27 percent, and West Germany's by 41 percent. Over the 12-year period, 1968–1980, investment in industry in basic research as a fraction of net sales declined by 32 percent.

Similarly, investment by the Federal Government in basic research as a fraction of the Federal budget declined 27 percent over the same period. Overall, R. & D. spending by the Federal Government as a fraction of the Federal budget decreased 36 percent. There are other worrisome indicators as well. At a time when domestic U.S. patents have decreased by almost 25 percent, U.S. patents of foreign origin have increased by more than 70 percent. Thus, the foreign origin share of total U.S. patents increased from 20 percent in 1966 to 36 percent in 1977. On top of this, we must remember that much of the R. & D. in the United States supported by Government is for defense purposes. If we look only at civilian R. & D., then we see that as a percent of GNP, civilian R. & D. in the United States rose only 10 percent during the past 14 years; in West Germany it rose 30 percent, and in Japan it rose 25 percent. Is it any wonder therefore, that during the same period manufacturing productivity rose 30 percent in the United States, 85 percent in Germany, and 290 percent in Japan?

With statistics like these, with the knowledge that 40 to 60 percent of all technological advances occur as a result of doing basic research, and with studies showing that advances in knowledge constitute the single most important source of productivity gain in economic expansion, does it make sense to have a handsoff national policy on R. & D.? Does it make sense to have a policy that removes the prime source of investment in basic research, the Federal Government, from a good part of the game, in the hope that private industry will take up the slack? I submit that to even ask the question is to already give the answer, and the answer is a resounding "no."

In addition to the huge underinvestment in R. & D., that has been occurring in the United States over the past 15 years, we are failing to produce the technical people that we need to sustain needed increases in productivity and to make advances in knowledge that will be the basis for our economic prosperity and national security in the coming decades.

For example, last year American colleges and universities granted 58,000 degrees in engineering. By contrast, Japan, with roughly half our population, graduated 74,000, and the Soviet Union graduated about 300,000 engineers. In the field of computer science there is an estimated demand for 54,000 graduates at the bachelor's level, but we are only supplying 13,000 graduates. The estimated demand at the master's level is for 3,400, and at the doctoral level the estimated demand is 1,300. whereas last year we only graduated 330.

The intense demand for technically trained people has resulted in high salaries that are luring faculty and graduate students away from even our best universities. The result is unfilled faculty positions in our Nation's engineering colleges, and a dramatic drop in the number of science and engineering students who are going on for advanced degrees. In 1979 for example, a full 46 percent of U.S. doctoral degrees in engineering went to foreign students—two-thirds of whom were studying here on temporary visas.

To complete this dismal picture, there is mounting evidence that the research labs and instrumentation in American universities are rapidly becoming obsolete. According to an ASEE assessment, the engineering teaching equipment found in most university labs is 20 to 30 years old and equipment to teach new growth technologies is almost nonexistent. Few colleges and universities can afford expensive computer-aided design or computer-aided manufacturing teaching equipment. Yet, without such modern equipment efficiency of output is sacrificed, promising areas of research are foreclosed, and the ability of our universities to attract and retain top-quality professors and graduate students is further diminished.

THE REAGAN ADMINISTRATION RESPONSE

In the face of the international challenge that I have outlined, and in the face of the clear indication that an expanded national R. & D. effort is needed to shore up our productivity, strengthen our national defense, and halt the scientific braindrain, what has been the response of the Reagan administration? Let us examine four specific ares: Energy, space, science education, and the national labs.

Energy

For over 3 years I worked, and jawboned, and cajoled the Carter administration to increase its funding in energy R. & D. in the areas of solar and renewables and conservation. My goal was to have this R. & D. funded at a level which would represent at least 1 percent of the cost of our annual oil import bill which was projected to be about $80 billion in fiscal year 1982. We finally got this amount and a bit more in the fiscal year 1982 budget request submitted in January 1981—about $777 million in solar and renewable energy R. & D. and $336 million for energy conservation R. & D. And then what happened?

At a time when the Pentagon was asking for billions more for defense—a goodly portion of which was justified on the grounds of maintaining our access to foreign oil supplies, the new administration cut $487 million or 62 percent from solar and renewable R. & D. and $248 million or 74 percent from energy conservation

R. & D. for fiscal year 1982. That was in the revised fiscal year 1981 budget submission by President Reagan, presented to the Congress on March 15, 1981.

On September 15, 1981, another revised budget submission came along calling for additional cuts of 12 percent across the board. In trying to save some of these programs, Congress deferred funding for some programs from 1981 to 1982. Thus, for fiscal year 1982 the amount of money available for R. & D. in solar and other renewables is $374 million, while R. & D. funds for conservation for fiscal year 1982 amount to $144 million. DOE's own Energy Research and Advisory Board (ERAB) disagreed with these cuts. In their report of November 1981 they stated that:

". . . R. & D. funding for energy conservation and end-use technology is underfunded, particularly when compared with funding levels for supply technologies. A balance . . . should be achieved by increases in funds allocated to buildings and community systems and industrial conservation."

So, what is the Reagan administration's response to the ERAB report's recommendations? In fiscal year 1983 the Reagan administration is requesting a total of only $18 million for energy conservation R. & D., which is a cut of 87.5 percent from fiscal year 1982, and a cut of 95 percent from the original Carter fiscal year 1982 figure. All this at a time when the Japanese Government has doubled its investment in conservation. France's investment has increased 221 percent, and Germany's commitment increased 66 percent to a level of $1 billion. In the case of solar and renewables R. & D. the Reagan figure for fiscal year 1983 is $83 million. That represents a cut of 78 percent from the amount available in fiscal year 1982 and represents nearly a 90-percent cut from the original Carter fiscal year 1982 figures.

The impact of these cuts is incalculable. The programs that are being zeroed out include the industrial energy conservation program, the transportation energy conservation program, which includes the all-electric and hybrid vehicle research and development, the buildings and community systems conservation research program, which includes the energy efficient buildings research program at the Lawrence-Berkeley Laboratory, and the energy storage program, which includes long-term, high-risk battery R. & D. that could make electric vehicles and utility load-leveling devices possible, as well as eliminate some of the practical difficulties that arise from the use of solar and renewable energy technologies because of their intermittency.

These budget cuts may be pennywise in this year's budget, but they are absolutely pound stupid for the long-term interests of this Nation. Cutting basic research funding of this type is almost guaranteed to prolong the dependency of the free world on the Arabian Gulf, and the mammoth outflow of money that goes with it.

The energy efficient buildings research program at the Lawrence-Berkeley Laboratory has a 1,000-to-1 potential return on investment. It has been costing the Nation less than $10 million annually, but has been producing technology and knowledge which have the potential of saving consumers and business more than $10 billion annually. None of this research is likely to be taken over by the private sector. For less than $1 million, this program produced an innovation in high-frequency ballasts for fluorescent lamps that advanced the adoption of these ballasts by 5 to 10 years and saved the U.S. ballast industry from severe foreign competition. The electrical savings are about 35 percent. The importance of that figure becomes obvious when I tell you that the electricity used to run fluorescent lamps in 1981 is estimated to be approximately the output of 40 base-load powerplants and costs businesses nearly $10 billion. So every 10-percent gain in efficiency saves a billion dollars a year and the equivalent output of four powerplants.

The industrial energy conservation program also has major achievements to its credit. It produced innovations to coil coating, textile foam finishing, crop residue grain dryers, granulated fertilizer production, efficient slot forge furnaces, high temperature recuperators, and cogeneration. The potential energy savings coming out of this program were of the order of many tens of millions of barrels of oil equivalent per year, and of course, these are savings that would occur every year once the innovation is in place. All this for an investment which last year amounted to less than $50 million. Once again, there is no evidence that the projects that were being worked on under this program would be taken over by private industry.

In the case of the energy storage program, the decision by the Reagan administration to zero this program out is particularly egregious in my view. We are presently in the middle of a technological race to develop a suitable battery capable of being used in electric vehicles or in utility load-leveling markets. A number of laboratories in Western Europe, Japan, and the United States have entered this competition, the result of which is a worldwide renaissance in battery technologies. About 10 advanced battery systems are being developed for this application and many technical advances have been made.

The Department of Transportation estimates that 92 percent of the noncommercial driving in the United States is done within 20 miles of our homes. General Motors and Ford have said that they intend to market electric vehicles as soon as battery technology permits. However, the technical barriers are numerous and difficult. There are cost barriers making for narrow profit margins. There are technical risks. The potential savings by the year 2000 could amount to over 400 million barrels of oil equivalent per year, not to mention the possibility that powerplants which are currently being planned might not have to be built, thereby freeing up a huge amount of investment capital for other purposes.

Does the administration really, seriously believe that the private sector will take up the slack in all these scientific areas that are being abandoned with such dispatch?

Here's what DOE's Energy Research and Advisory Board said about the new policy:

ERAB is concerned that some energy R&D of great potential significance for the achievement of the nation's energy goals will fall between Federal and industry responsibilities.

"The new policy recognizes that private industry cannot be expected to do *basic* energy research or projects of a long-term, higher risk character, but there are other circumstances in which it would be unrealistic to expect timely and effective assumption by industry of R&D responsibilities abdicated by the government, however worthy the projects involved, and despite the provision of new generous tax incentives."

Thus, I ask again. Should our future be determined only by the private sector's response to the level of market prices for commodities like oil? I submit this is risky at best, and may be downright dangerous for the future welfare of our country. We need look no further than to an unusually candid interview given to a pro-government Saudi newspaper in Jidda by Sheik Ahmad Yamani. In the interview, he stated that Saudi Arabia has opposed recent petroleum price increases because increases in 1979 and 1980, "caused a great rush toward investment in energy technologies, with the aim of reducing consumption and developing alternative energy sources. . . . This has resulted in a drop in OPEC's share of the market from 31 million barrels per day in 1979, to less than 24 million barrels a day this year". Yamini goes on to say that such Western actions could further reduce OPEC's leverage in the future which would mean "the end of the organization". He finally adds that keeping prices low enough "to curb investment in alternative sources," will insure continued Western dependence and Saudi Arabia "will be assured of obtaining income sufficient to meet its financial requirements for the next 20 or 30 years." Well, its all in that statement. If we refuse to be farsighted enough to provide investment in alternative sources and in conservation in order to keep up our technological base and prepare us to switch to alternative fuels in the future, we will be forever condemned to be at the mercy of the OPEC oil producers who are honest enough to state that they intend to keep the price low enough so that any strategy for obtaining alternatives through market forces will fail.

Space

If you think that what the Reagan administration is doing to energy R. & D. is ridiculous, wait till you examine their decisions on the space program. The fiscal year 1983 budget for space shows sharp reductions for the planetary program. The Galileo program is now the only remaining U.S. planetary program in development. The Venus orbiting imaging radar mission which was postponed by the Reagan administration last year, is canceled this year and the fiscal year 1982 operating plan deletes the $10 million provided by Congress for this project. They are even cutting the research and analysis line items for planetary programs. The argument has been made that the United States can forego planetary exploration for the next decade because we still have a great deal of data from past spacecraft to analyze, but now the funding is being cut for this data analysis function. In addition, some of the older space probes which continue to return data from their locations in space may be turned off because of insufficient funds for continued tracking and data acquisition. This action would affect Pioneer-10 which is now the farthest manmade object from Earth. Funds have also been cut for technology transfer and technology utilization programs, as well as for the construction and launching of a satellite to test new advances in communication. Last, but of extreme importance to our economy, aeronautics research and technology has been cut by more than one-third from NASA's original request to OMB—this for a program which helped us to achieve and maintain our technological lead in commercial aircraft around the world and which the Department of Defense still says is important to our national security. And I say "of extreme importance to our economy" because sales abroad of U.S. aircraft are second only to agriculture in our balance-of-payments tally sheets. Is this the time to cut back on aeronautics research, at a time when the Europeans are challenging us with the development of the airbus, when the Japanese and even the Brazilians are thinking of launching major forays into the international aircraft market? I submit once again the answer is "no."

And, more generally, what about all of the technological spinoffs from the space program that have helped to raise our standard of living and that have kept us ahead in the international race for technological supremacy? I am talking about satellite communications technology, the microelectronics industry, and hundreds of new consumer items based upon new materials for packaging and clothing. Is turning off this type of activity what we should be doing at a time of increasing international competitiveness? Is this what you would call leadership, foresight, and orientation toward the future? Not in my book.

Science education

The administration claims that it is interested in the future. That it is interested in supporting long-term, high-risk, potentially high payoff R. & D. activities which the private sector will not support. They like to point to the increase in the budget of the National Science Foundation, which is up by 7.7 percent for fiscal year 1983 over fiscal year 1982 if you do not take inflation into account. What the administration prefers to ignore is the zeroing out of NSF's request for funds to upgrade university laboratories and, in addition, the 70-percent reduction that they forced on NSF in the science education budget. Now is not that a wonderful way of insuring that we will get the amount of engineers and hard scientists that we are going to need in the future? I wonder if the administration is considering population and demographics. The birth rate has gone down and college-age populations are going to be decreasing for a number of years into the future. Besides that, only 6 percent of U.S. college graduates are engineers or hard scientists, as opposed to over 35 percent in West Germany, or 20 percent in Japan. We are right to be concerned as to whether we will be able to meet the demand for technical people in the future. We are also right to be concerned about whether we will continue to have the kind of social and political climate in the United States that is supportive of the work of technical people. All of this requires better scientific and technological literacy within our population. But for the sake of saving a few million dollars at the National Science Foundation the administration is willing to give up on attempts to create more scientifically and technologically minded young people. That says a great deal about the administration's attitude toward the technical manpower of tomorrow.

The national labs

What about the technical manpower of today? Here is what is happening at our national laboratories. At Argonne, which is deeply involved in energy and environmental research, 600 positions already have been cut. The laboratory's Director says 600 additional employees may have to be laid off. At Brookhaven National Laboratory, 270 of 3,600 employees have been laid off and officials say further cuts may eliminate 25 percent of the work force within the year. At the Fermi National Accelerator Laboratory, which I talked about earlier, the staff was trimmed by 200 people after the March budget projections, about 12 percent of the staff. The laboratory's Deputy Director has been quoted as saying that an additional 200 to 300 people may be let go in a worst-case situation. At the NASA Lewis Laboratory in Cleveland, a center which employs 2,700 persons, and which some years ago employed 5,500 more than 200 full-time equivalent slots are scheduled for the ax in 1983. The Jet Propulsion Laboratory at Pasadena may end up having so little to do because of the cutbacks in the planetary program at NASA that its best people will inevitably start drifting away.

The administration seems not to realize that it takes 8 to 9 years to produce a Ph. D. scientist, and years and years and years to assemble a topnotch research team and carry a project to fruition. When funding disappears even for a year, so do the people, they cannot just sit and wait, highly competent teams breakup, teams that are valuable national resources—and you can not necessarily bring them back without additional years of build-up later on.

As Dr. John McCarthy, head of the NASA-Lewis Laboratory put it:

"It is time that this country came to its senses and supported the vital research and technology necessary for national economic health. Cyclical, inadequate funding is the road to disaster."

He is absolutely right. This Nation is what it is because we have from our founding days put more effort into pushing back the frontiers of knowledge, of learning the new and putting it to work, than any nation in history.

Why Government Support of Research is Necessary

The mood in this administration, and in many places outside it, that Government should leave well enough alone, even in the R. & D. area. In answer to that let me quote what President Harry Truman said to a joint session of the Congress on September 6, 1945, only 3 weeks after VJ Day:

"Progress in scientific research and development is an indispensible condition to the future welfare and security of the nation. No nation can maintain a position of leadership in the world of today, unless it develops to the full its scientific and technological resources, No government adequately meets its responsibilities unless it generously and intelligently supports the work of science in university, industry, and in its own laboratories."

We must remember that much industrial R. & D. is devoted simply to meeting the requirements of Government regulation, rather than to the kinds of risk-taking research that promises true technological breakthroughs. Basic research by definition will rarely result in an immediately salable end product, so it is not attractive to most businesses. But, it is the new information that comes together that makes later commercially usable products possible.

Let me be clear. In no way am I suggesting that the Government should seek either to compete with, or supplant the business community's research and development efforts. Both efforts should be complementary and ,wherever possible, symbiotic.

I have spent a lot of time giving my views on what is wrong with our present situation in the area of science and technology, research and development.

Now I want to say a few words about what, specifically we ought to be doing about it.

First. Increase financial support for scientific and technological research. We should restore funding for research programs that have potentially high payoffs and which the private sector will not pick up. Government funding for basic research should be stable and predictable, and should be given on a multiyear basis for selected fields of particular importance to the health of our economy or national security. Such stability of funding should be available to our best universities, nonprofit research institutions, and Government laboratories. In addition we must upgrade the equipment in our university laboratories. Finally, we should remove artificial impediments to increased support that have hampered the ability of the Department of Defense to support basic research along a sufficiently wide spectrum.

Second. Alleviate shortages of technical personnel with advanced training, including faculty at our schools of engineering. Our brightest students should be given incentives to go on to postgraduate training, and our scientists must receive adequate compensation commensurate with their abilities and contributions. Incentives for industry-endowed university chairs and/or the use of industrial laboratory equipment for graduate training and research should be explored.

Third. Provide incentives for better university-industry cooperation in areas of both basic and applied research. Industry must recognize some responsibilities to support the training of the next generation of scientists that will be of use to it, and the universities should recognize that raising the health of our techonology is part of the key toward increasing the economic benefits that mean more support for university activites. At the same time, we must insure that increased university-industry cooperation does not lead to a significant loss of university independence to play its traditional role of pursuing knowledge for its own sake.

Fourth, Improve and expand science and mathematics education at our primary and secondary schools. We can build the society of the future only if our population is scientifically and technologically literate. A first step in this direction is to restore the science education program at the National Science Foundation. In addition, we must explore ways of increasing the supply and training of science and math teachers at the precollege level.

Fifth. Improve the climate for research, development, and technological innovation within the private sector. We should seek to implement additional incentives for R. & D. wherever necessary and effective. In this regard, a reexamination of our patent policy would be valuable. We should also reexamine our antitrust laws to see if we have unnecessarily restricted cooperative R. & D. ventures within industry.

Sixth. Develop a coherent national science and technology policy, and raise the visibility and the voice of the science and technology community in the making of such policy. Decisions about support for research on energy, space, and health should not be made only by lawyers and accountants. If the Office of Science and Technology Policy cannot be sufficiently effective in this role then we should start thinking seriously about creating a Cabinet-level Department of Science and Technology as a focal point for Federal nondefense research activities. Such a Department could probably include the present Department of Energy's energy research and development, NASA, the multiprogram national labs, NSF, NOAA, NBS, possibly the major Federal statistical agencies, and possibly a national engineering foundation to do for applied research what NSF has done for basic research.

It is my intention to introduce legislation to deal with some of the above issues in the near future.

Another point: From all the above concerns, and through all the generations since our founding days, has come the matrix of new ideas that has provided the new industries, the new businesses, and products and services to trade not only domestically, but in international commerce.

That has meant jobs, employment, Americans at work in fields the rest of the world will follow. Short-term job protection in the United States may benefit from tariffs on quotas on foreign imports, but stable long-term jobs into the future can and will come only from our willingness to stay ahead of the world in information, in knowledge, in new ways of doing things, in out-inventing, out-researching, out-innovating, and out-producing any other nation on Earth. We will not maintain that preeminence by default, we must earn it. It is the key to jobs for the future and the economic health of our Nation in an increasingly competitive world.

I invite my colleagues to join me in sending a message to the executive branch of our Government. The message is that greatness cannot emerge from the stifling of either macro- or micro-exploration of the unknown in the name of economic ideology; that the future will not be ours if we seek only the return of the past; that we have cast our lot as a people and a nation with giving man the freedom and the resources to use his ingenuity to find a better way—and that our character as a people is reflected by our commitment to this ideal.

Senator **Glenn**. I will say, simply, Mr. Chairman, that America's prosperity, national security, and spirit of optimism depend in significant measure upon America's maintenance of worldwide leadership in research and development, particularly in scientific and technological areas.

We are seeing worrisome trends in terms of declines in our rate of productivity and innovation relative to other nations, shortages of technically trained persons in certain key areas of our economy, and increasing competitiveness by other nations in areas in which the United States stood supreme not so long ago.

I think that the massive budget cuts by the Reagan administration for federally supported nondefense R. & D. threaten to make our situation even worse in the future because there is little evidence that the private sector is prepared to take up the slack.

If we are successful today as a nation, it is because we had the foresight and good sense to invest heavily in R. & D. in the past. This link was eloquently made by President Harry Truman in an address to a joint session of Congress on September 6, 1946. He said:

> Progress in scientific research and development is an indispensable condition to the future welfare and security of the nation. No nation can maintain a position of leadership in the world of today, unless it develops to the full its scientific and technological resources. No government adequately meets its responsibilities unless it generously and intelligently supports the work of science in university, industry, and in its own laboratories.

I think those words are as true today as they were when spoken, in 1946. I think we must insure that we do not lose our momentum in this R. & D. area as a result of the administration's slavish devotion to an economic ideology that is producing unworkable policies.

I am sorry that Dr. Keyworth could not accept the invitation to present the administration's position on this most serious issue confronting our country, but we are glad to have Dr. Pewitt here, of course.

I would also, at this time, like to greet our other witnesses who will testify this morning.

Mr. William Carey, executive officer of the American Association for the Advancement of Science will, as part of his testimony present the AAAS "early bird" analysis of the President's budget for R. & D. The early bird analysis is a cooperative exercise that involves some 16 professional scientific, technological, and educational societies.

Dr. John Deutch, dean of science at MIT and former Undersecretary of Energy and Director of the Office of Energy Research during the Carter administration will give us his views on the President's science policy, particularly as it pertains to energy.

And last, but far from least, Dr. Carl Sagan, director of the Laboratory for Planetary Studies at Cornell University, will also give us his view of the President's science policy, with emphasis on space sciences and applications. And I am told that Dr. Sagan will be giving a lecture later today in room 1202 Dirksen on the search for extraterrestrial life.

Dr. SAGAN. That is not what I am talking on.

Senator GLENN [presiding]. I was about to say, I don't know about extraterrestrial life, but I am certain there will be plenty of terrestrial life listening to that lecture.

I am sure, Dr. Sagan, we will welcome any lecture, and I hope to attend that myself.

Dr. Pewitt, to just recap a little bit of the longer statement that I had put in the record the other day, I worked for 3 years getting the Carter administration to address what I thought was an important item, that is the area of energy supply research and conservation research. And our objective at that time was to get spending authority for just 1 percent of the amount of our OPEC oil bill, our offshore bill, which was running about $80 billion at that time.

The last budget the Carter administration submitted was one that had some $776 million in R. & D. that was devoted to solar and renewable alternative sources, plus additional amounts for conservation research. I thought that was pretty good, it covered most of the areas that we had looked at over a 3-year period and I thought it was a very good budget. The new administration came in and cut back $487 million. If you go into the conservation we begin talking about 70 to 80 percent cuts in those areas. Many programs were actually zeroed out.

At a time when we are building up a defense budget to defend the Persian Gulf, among other places, I can't think of anything that better guarantees our dependence on the Persian Gulf for a long-term period than cutting back on research and other energy sources.

How can we possibly justify that in the new administration? Because private industry is not taking up that research.

Mr. PEWITT. The argument that R. & D. would relieve our independence in the Middle Eastern oil depends on a very long timeframe for this R. & D. to in fact be accomplished and be effective.

I think that by the deregulation activities, by the building up of strategic petroleum reserves we adequately address the near-term problem.

On the other hand, we can look at massive Federal investments on energy and R. & D. over the last decade admitting the fact that R. & D. takes a long time to have effect, but we have a difficult time seeing any real effect on the supply problem through that R. & D. effort over that decade.

Senator GLENN. What was the R. & D. effort? We got it put in the budget and it was defeated before it was put into effect.

Mr. PEWITT. The Federal Government has invested over a period of time many billions of dollars on all sorts of energy technologies and we have not seen much of that, and we don't expect to. The fact that there is a deregulated oil market now and quite sufficient incentives for private sector investments, we believe relieves the Federal Government of the responsibility to make direct investment in that R. & D. That is the policy of the administration.

Senator GLENN. As the President stated: If it is worth doing, private industry will do it?

Mr. PEWITT. I don't think that was quite in the same context, but that essentially is correct.

Senator GLENN. I don't know of any area on which I disagree with you more than that. Because when you have a business that is focusing on the bottom line on their balance sheet, and it isn't coming out right and they are trying to make ends meet, to assume that they are going to pick up the basic kinds of research that we need in some of these areas is just wishful thinking. When we see other nations going ahead of us in these areas, it is preposterous to think that business will do that. I think there have been basically three reasons why this Nation has gone ahead of other nations around the world in our short time period of history: One is education; we left that pretty much up to the States and local areas, while we give some Federal support. We are seeing the Federal support to keep some of our brighter students in school now being cut back. That is No. 1; No. 2, we have always devoted considerable resources to research and out of this has come the new innovation; and then third, capital, to take the innovation and make business out of it, make jobs, employment. And all we are doing right now is concentrating on the economic part of it to the detriment of the other two. And I think over the long haul for this country that is tragic.

We have difficulties not just in the energy area, but in other areas. I have some experience with our own NASA-Lewis Laboratory up in Cleveland. They are being cut back in satellite communication at the time they are the leaders in that particular area for this country. They are being zeroed out, as I understand, on some of these areas. They have been doing research on internal combustion engines with the hope that we might be able to get our engines above a 35-percent or so efficiency rating. Their research on that is going down. Their research on aerodynamics is being zeroed out with some of the finest wind tunnels in the world that will not be getting used as they should be used.

If I had one energy wish I would have granted before we leave this hearing room, it would be better electrical energy for storage. We know how to convert windpower and use photovoltaic cells to produce electricity, but we can't store it. The wind does not always blow when I want to have my TV set on in the evening. And massive storage, such as the Redox system up there, for lack of a half million dollars, I was told, we are not going ahead with the pilot plant on that, and private industry is not willing to pick up that kind of basic research.

Where are we going? We are cutting back on these things that are so vital to the future of this country, as I see it.

Mr. PEWITT. A couple of points in responding to a lot of questions in one.

Senator GLENN. I get going on this subject and I get too many subjects in one question. Answer the whole problem.

Why are we cutting back on these vital areas? They are crucial.

Mr. PEWITT. We know the administration cannot do all of the things in the area of technology that seem like good technology ideas. If we ever get to the point that we are funding all the good technology ideas, the whole Federal budget will be devoted to R. & D. because one of the things about our technology community is they do continue to come forward with ideas.

With regard to support of basic research. In fact, we agree that the Federal Government should support basic research and we provided in very difficult circumstances significant increases in the basic research across-the-board in the Federal Government. I think overall it is up by 8 or 9 percent.

Senator GLENN. For this year?

Mr. PEWITT. Yes, sir.

Senator GLENN. After being butchered last year. We are not back to restoring what you cut back last year, if you allow for inflation.

Mr. PEWITT. Our information is that in the mathematical and physical sciences and the areas that principally underlie our productivity, that the overall growth is above the estimated GNP deflator over 1981. We specifically looked at those areas carefully. It is something in excess of on the order of 15 percent over 1981. So we think that in the area of basic sciences and physical sciences and mathematics, chemistry, and those things, that we have maintained strong commitment to that level.

As a percent of GNP, I think the United States compares very favorably to almost any other free world nation. When you take a look at Federal expenditures and when you take a look at our total national expenditures we compare very favorably. The fastest growing area of research support over the decades of the 1970's has been the private sector and I think 1980 or 1981 is the first time when private sector R. & D. in fact those expenditures exceeded the Federal Government's expenditures for the first time and they are still growing significantly faster than inflation and expect that trend to continue.

Senator GLENN. Let me tell you where that comes apart. Fifty-seven percent of the R. & D. money goes into defense research, in Germany only 8 percent goes into it, in Japan 1 percent, plus these other nations target theirs, they channel their research into the most promising areas. They don't ignore others, but they channel them into the most promising areas. We don't do that. We let people run free as to what they want to do research on. We need more money for that. Fifty-seven percent of our R. & D. is defense related. True, some of that will have a spinoff in civilian life. It has in the past, in aerodynamics, but certainly not enough to make up that huge difference.

Mr. PEWITT. The period of the decade of the 1960's, throughout that decade military R. & D. exceeded the private civilian sector investment by a considerable amount. We think in the areas of fundamental research, the color, whether it is olive drab or civilian blue, has little bearing on the ultimate end use of that research. We think that increased support in DOD will in fact have very significant beneficial effects.

Senator GLENN. Before I turn this over to Senator Levin for his questions, because I know he does have to go, can you answer those things I mentioned for the NASA-Lewis Laboratory, the satellite communications. We are letting other nations take the lead in that area even though we have done more science in that area, and, in addition we are seeing internal combustion research, aerodynamics research all being cut back or zeroed out.

Mr. PEWITT. I can speak with some knowledge about internal combustion research, and I think that research capabilities that are inherent in the automobile companies in Detroit are quite adequate to handle any commercial sizable development that is liable to be needed for the American automobile. It is a question of their making those judgments. The Federal Government should not intercede in the private sector decisionmaking of that type.

In aerodynamics, I am simply not aware of what is happening at Lewis.

Senator GLENN. Let me give you an example. Gas turbines. If we can get the temperature high enough and we can use the smaller gas turbines, those have great promise for the future. Would you agree with that? You are an expert in this area.

Mr. PEWITT. I think that the promise can be realized when there is a market out there that the people who manufacture the automobiles decide that is the sensible thing to do. It doesn't require Government intervention in that area.

Senator GLENN. Let me give you an example. Lewis did some work on ceramic coating for turbines that I am sure you are aware of, very fine, original, basic research work that I don't know of any other place doing, and they now have a tiny rotor, about this big, that replaces one much bigger because they can go to higher temperatures, higher RPM's. It's beginning to look as though the gas turbines may be practical and we are zeroing that program.

Why would we do that? That work wasn't being done in Detroit. Those are the kinds of basic breakthroughs that we are looking for. It shows the serendipity of basic research that private teams don't get into. And we are zeroing out programs like that and saying private industry will do it in Detroit. They are not. They are not doing work on ceramic coating for turbines as the Government was.

Mr. PEWITT. We are having a small problem of sematics. You use basic research with a direct application in mind and by all of the jargon that I am used to, that is called applied research.

Senator GLENN. I agree with you. If I gave that implication to it, I didn't mean to do that. I am talking about somebody over here doing basic research in ceramics, an application of which happens to be for this turbine. That ceramics research was not something that private industry was doing.

Mr. PEWITT. And we believe it is appropriate for the Federal Government and its laboratories to continue that type of fundamental research to increase our bank of knowledge and our fundamental technology.

Senator GLENN. Why are we zeroing it out?

Mr. PEWITT. However, we are concerned about the fact that the laboratories do not make that information adequately available to the private sector to make those applications. This is one of the things our office intends to look at very carefully. We think that we should look at the structure of our R. & D. enterprise rather than just to accept the fact that it won't be done and then fund it. We want to find better mechanisms to get that work to Detroit, because that is where they make automobiles, unfortunately, not Lewis.

Senator GLENN. I agree with you. But that is exactly one of the biggest programs NASA–Lewis has had, and, as I understand it, funding is being cut back for the technology transfer program; is that correct?

Mr. PEWITT. We think that the incentives in the laboratory should be structured so that we do not need a separate technology transfer bureaucracy. That ought to be something by which the laboratories and the scientists are judged.

Senator GLENN. How?

Mr. PEWITT. We develop mechanisms to do that.

Senator GLENN. If you don't have money for printing the papers to give the information to send to the manufacturers to make it available, it will remain secret forever.

Mr. PEWITT. The question of information transfer, technology transfer, is a very complex question. The mechanisms that do it most effectively I don't think have been determined yet. And I am not aware of a separate decision—certainly it is not a policy decision, to reduce the technology transfer program of NASA. I wasn't aware of that. But we are certainly concerned about that transfer and the effective use of our resources in those laboratories to get them out to the private sector.

Senator GLENN. We didn't get to the satellite communications and aerodynamics research. I will get back to that later.

Senator Levin?

Senator LEVIN. Thank you, Mr. Chairman.

Do you ever see an occasion when the national interest is different from the market interest?

Mr. PEWITT. Absolutely. We clearly differentiate where the national interest will not be served by private——

Senator LEVIN. In other words, there are occasions when the market is not going to produce an outcome which is in the national interest?

Mr. PEWITT. We think that the market will work effectively in the national interest whenever the activities, the individual investment, can capture the benefits of those activities. In the case where individual investment cannot be rewarded from successful efforts, then we think it is appropriate for the Federal Government to step in.

However, we do think that the Federal Government has gone way beyond that point and has, in fact, inhibited achieving national interest because we have driven out much private initiative and private investment.

Senator LEVIN. But there are occasions, I am sure you think they are relatively few, but there are a few occasions at least when the national interest is not going to be achieved by a pure free market?

Mr. PEWITT. Certainly no one has offered to come forth and run the Pentagon for us.

Senator LEVIN. Is it possible that the free market is not going to produce energy-efficient automobiles, if there is a glut of gasoline. Is it possible?

Mr. PEWITT. Energy efficiency is only one factor in the economic equation. I think the free market will produce an optimal economic solution.

Senator LEVIN. Did the free market produce an energy-efficient automobile in this country before we mandated certain mileage be achieved by automobiles?

Mr. PEWITT. No. But I think if the market had been there that they would have moved toward it. The Federal Government's intervention in those areas didn't make it happen a whole lot faster either.

Senator LEVIN. You would have been opposed to the setting of those fleet averages in order to increase fuel economy if you had been making the policy at that time?

Mr. PEWITT. I think the administration would have. I don't speak from any particular policy position, but I suspect that the administration would have.

Senator LEVIN. I think the administration would have, too, and I think the results would have been even more catastrophic. Had we not had those economy requirements in place, we would have been even more at the mercy of OPEC than we are now.

I think there is a basic philosophic difference at the heart of this whole matter. You, for instance, use the rhetoric that by any measurement the field is healthy. We look at cuts in R. & D. and energy and a lot of other areas and we say if that is healthy, for God's sake give us sickness.

There is a basic philosophical dispute which is not going to be resolved here. But I want to move away from that and get to slightly different questions.

Is all the money which can usefully be spent for long-term research in this budget requested—we are talking about the energy budget, we are just talking about your basic research.

Mr. PEWITT. As Dr. Deutch will tell you later, and we all know, if we ever funded all the clever things that fundamental scientists could propose for us to fund, we would break certainly the National Bank.

Senator LEVIN. Let's get away from the prerogatives. In your opinion, is all the money which can usefully be spent on basic long-term research included in this energy R. & D. budget?

Mr. PEWITT. The appropriate amount of money given the fiscal constraints is in fact being invested in that area.

Senator LEVIN. Let me ask my question again because you are not answering. Is all the money which in your opinion can usefully be spent in long-term basic research in the energy R. & D. budget? I am not talking about all the other budget needs of the country. I am asking you for your opinion as to whether or not all the money which can usefully be spent in long-range basic research in energy R. & D. is in this budget?

Mr. **Pewitt**. And I will repeat the statement, that there are clever ideas that the research community can advance that will not be funded in this budget.

Senator **Levin**. Are they useful ideas that can't be funded?

Mr. **Pewitt**. It is hard to decide the usefulness of basic research. And one of the problems, one does not fund for its usefulness but one funds in the belief that aggregate useful things will result in the future.

Senator **Glenn**. How do you know one of these clever ideas isn't as clever as Fleming's curiosity about green mold slowed the growth and reproduction of bacteria, and began research that ended with the discovery of penicillin and the development of antibiotics which resulted in longer life which gives us trouble in the entitlements because everybody is living longer?

Mr. **Pewitt**. For many years I have lived with the difficulty of having to face that choice because certainly you cannot fund everything. One uses the best judgment. Fortunately, I am not in the direct funding business anymore, other people have to agonize over that.

We have tried to apply as much of the budget resource as we could justify to this area of research and that has been our role in the recent past.

Senator **Levin**. Would you like to see this budget increased for long-term basic R. & D. energy?

Mr. **Pewitt**. I would like to keep my job, so my answer is no.

Senator **Levin**. Putting aside your own self-interest.

Mr. **Pewitt**. I can only repeat the administration's position up here, I am sorry.

Senator **Levin**. You are not able to give us your own honest assessment?

Mr. **Pewitt**. If I could not reconcile myself to support the R. & D. budget that we have presented to the Congress, I would not have been up here to testify.

Senator **Levin**. Let me repeat, does your approval provide for government augmenting the private sector investment where we could accelerate research and development in an area of great national concern?

Mr. **Pewitt**. No, not in the private sector. We do not believe that the Federal Government, by intervening in R. & D. in fact, accelerates anything. We think that the Government in fact lays a dead hand on initiative and in fact delays accomplishment of many of these worthy missions.

Senator **Levin**. I want to go back one more time to what I think is the basic question. But I want to go at it a different way.

There have been drastic cuts in R. & D. and the energy field, lots of other civilian areas too. It has, I think, the most radical bit of surgery I have seen around here in a long time. I don't consider this a conservative budget, I consider it a radical budget.

Let's take a look at fossil energy R. & D. reduction from 1982 to 1983 from $416 million to $106 million, a 74-percent reduction.

Is the message we are supposed to get from that that in 1982 only $106 million, roughly, was used in basic long-term research and the rest was used in areas of technological development of demonstration projects? Is that the proportion of how the expenditures were used in 1982?

Mr. Pewitt. That was felt to be the number that was consistent with the overall science policy that was appropriate for Federal investment which if we did not do would not otherwise be done by the private sector, yes.

Senator Levin. My question is this. Of the $416 million we authorized and appropriated in 1982, was 75 percent of that spent on technological development and demonstration projects as contrasted to long-range research and basic research?

Mr. Pewitt. The number escapes me right now. But in the 1982 budget there was phase out of some of that activity that was expected to be done in 1982 and therefore the level we achieved in 1983 was the estimated amount of long-term research appropriate for the Federal Government.

Senator Levin. Are you saying we spent in 1982 dollars in the ratio of 3 to 1?

Mr. Pewitt. I am surprised it is only 3 to 1, to be perfectly honest.

Senator Levin. And that ratio was decided by the DOE?

Mr. Pewitt. No; it was not decided by DOE. It was decided by the administration based on a careful examination of the programs that were proposed by DOE.

Senator Levin. With the 1982 budget, could we have shifted that ratio around and spent 50 percent if we wanted in long-term basic research and less on demonstration projects?

Mr. Pewitt. I think 1982 was the phase out period where one was mortgaged to past investment and we were paying those off in order to phase out. In the 1983 budget we don't have the luxury, because of the overall economic situation, to continue that sort of phase out. We withdraw completely in the 1983 budget from some areas that were questionable in 1982.

Senator Levin. Do you know what that request was for R. & D. from DOE to the OMB?

Mr. Pewitt. I am not a budget examiner. I don't track that.

Senator Levin. You have not heard what that request was?

Mr. Pewitt. I am sure I have heard but the number escapes me. There are thousands of those numbers and the request was very complex this year because of two submissions.

Senator Levin. Do you know whether it was significantly higher than that which ended up in the President's budget?

Mr. Pewitt. I suspect it was. I am certain it was. I don't know what the level was and there was significant debate over that particular subject this year.

Senator Levin. Is that what you are trying to compute?

Mr. Pewitt. No, I am doing something else here.

Senator Levin. Thank you, Mr. Chairman. I think it would be useful if this subcommittee could ask the DOE for those figures as to what the requests were. I think at one point the Secretary said that he would think about at least for allowing us to have them after the budget came out. He didn't want to give us figures prior to the President making the decision on the budget number, but he indicated that he might be willing to do so after the budget was sent to the Hill. So, if we can make that request to DOE, that will be useful.

Senator Glenn. Staff will follow through on that. Thank you, Senator Levin.

I have a couple of other comments, and I know you have another commitment.

[The information referred to follows:]

	DOE request	Administration submission
Operating expenses	$4,458.4	$3,917.3
Plant and capital expenses	799.5	666.7
Total	5,257.9	4,584.0
Bonneville	22.1	22.1
Total	5,280.0	4,606.1

Senator Glenn. Can you tell me why we are cutting back on aerodynamics research?

Let me make a short statement on that. That is second in our balance of payments. Our aircraft sales are second in balance of payment only to agricultural items, and we have that lead and have traditionally held that lead since the days of the Wright brothers because we did more research, supported by Government because they were expenditures a private company could not and cannot be expected to take care of on their own. Wind tunnels and things like that are very expensive and we do that for the whole industry, and out of that has come an aircraft industry that is second to none.

I was out at Boeing not too long ago and in a casual lunch conversation I was commenting about how the American aircraft industry predominates around the world and they said, yes, not only that, but at any given time 50 percent of the airliners flying around the world are Boeing. But even Boeing, even with the billions of dollars' worth of R. & D. that they do cannot run all the wind tunnels that we run for the whole industry and for military research and aerodynamics research, research which is being cut back.

Mr. Pewitt. The aerodynamics area is one that was examined very carefully and based on the deliberations our office will be conducting a more exhaustive review of the aerodynamics programs. It was felt that some activities that NASA had been supporting were in fact within the capabilities of the private sector under our policies and the program was not increased over the 1982 funding levels. We have no intention of asking the private sector aircraft companies to operate the large wind tunnels. I don't know all the detailed decisions that were made in NASA and I suspect no one in our office does, but there is no policy intent to see us get out of the aerodynamics research in support of large national facilities.

Senator Glenn. That is being done, though.

Mr. Pewitt. I don't know of any wind tunnels at Ames being closed down. There may be some small facility that represents a programmatic judgment of NASA. But as a policy, there is no intention to close down any of the national facilities. It is our intention to look very carefully and make sure that we maintain what corresponds to the national resource that is appropriate to the Federal function.

Senator Glenn. Some of the unique and finest wind tunnels in the world are at NASA-Lewis up at Cleveland and the last time I talked to them they were planning to drastically reduce or terminate some of those programs they have on aerodynamics research, and that is unconscionable to me. We are going to lay down our aerodynamics lead. The Japanese are going into this area very rapidly indeed, and we have to outcompete. We are taking steps that will lead to our laying down our lead in this area. That is tragic.

Mr. PEWITT. I trust we are not. It is not our intention to lose our lead in aerodynamics. We intend to take a very careful look at that subject. I can absolutely assure you that Dr. Keyworth has no intention of seeing that science policy of this administration used to take apart our aerodynamics research capability.

Senator GLENN. Well, I think what is being done under the guise of budget cutting, and I have told this to Mr. Stockman, is perhaps pennywise in this year's budget but it is pound stupid for the long-term future of this Nation.

Just a couple of other areas here.

Mr. Pewitt, I have some difficulty with the administration's decisions regarding the U.S. space program. The fiscal year 1983 budget shows sharp reductions for the planetary program. The Galileo program is now the only remaining U.S. planetary program in development. We have dropped the Venus orbiting imaging radar and we have decided to have no mission to Halley's Comet despite the fact the Europeans, the Japanese, and the Russians will each have their own. Funding has even been cut for data analysis from space problems that have been sent up in the past. That includes Pioneer 10, which is now the furthest man-made object from earth. We are cutting back on funding for additional collection of and research on that kind of data.

Mr. PEWITT. I can speak to the science policy. I can't speak to all the thousands of programmatic decisions made in each agency.

From the policy perspective, we have provided the space science program what amounts to a massive increase of 20 percent over the 1982 levels.

Senator GLENN. Which gets us back into where?

Mr. PEWITT. It is up in real terms over 1981. That is a very difficult thing to do in these budget circumstances within priorities that we have to set. That is a very special and favored treatment for the NASA program and NASA overall.

Senator GLENN. What happened in so many of these areas is what happened with the one in which the President took such great pride in his state of the Union address. The only area of research he singled out was one where he said they are putting a $100 million increase into the NIH.

Mr. PEWITT. Yes, sir.

Senator GLENN. Can you tell me whether that even gets us back to where we were before we cut it last year?

Mr. PEWITT. The National Science Institute of Health is an area that has been very fruitful in the past and we continue to support the National Institute of Health very strongly. However, when we look across all Federal R. & D. activities, especially in the basic research, we see in the physical mathematical sciences during the decades of the 1970's, the total aggregate Federal support for those activities did not keep up with inflation whereas the life sciences showed an overall increase of in excess of 40 percent in real terms. We have to achieve some balance in our support and it is a difficult decision. It is good research, but we simply had to make some priority judgment about that.

Senator GLENN. Does this get us back to what we cut in 1981?

Mr. PEWITT. We do not believe that sound science policy is made on the basis of increments over previous years. We notice these things but we have to make decisions based on the internal dynamics of the field of science and not on some external indicator such as percent growth or GNP, those sorts of things.

Senator GLENN. Does this get us back to where we were in 1981?

Mr. PEWITT. In terms of real growth, I don't know. I can look up those numbers. I suspect not. There was no intention to, not as a matter of adjusted for expected GNP deflators.

Senator GLENN. I single that out because the President took great pride in that and I would submit after the cuts of last year that I think the $100 million increase there barely gets us back to what we had last year. Above all people should know, if you are talking about science policy, you can't run these things on a boom or bust basis. You don't chop them this year and put them in next year. It takes years and years to get scientific teams together, get them going, get their equipment. You can't cut them one year and put them back next year.

As you are well aware, we are seeing a great exodus. I think one of your efforts of the science policy that you in particular should be looking at is what is happening to some of our most talented people in these various areas. They are just jumping ship and going off to other pursuits because they see what is happening in this administration. You are having a personnel loss that is irreplaceable. It will be years even after the budget comes up again to restore the capabilities that some of those people have in the national labs right now.

Mr. PEWITT. We are concerned about that.

Senator GLENN. I hope so.

I know you were promised that you would be out of here by 10:30, and I know this has not been a very pleasant exchange for you this morning, but it isn't very pleasant for some of us who have had a long-term interest in what makes this country tick in the way of science and research to see the dissolution going on in our national labs and in some of the things that we think are important. We don't want to see the Government spending any money at all in areas where private industry, private business, private research foundations are covering. But I think the Government has not only the right, it has a duty to do research that keeps us ahead of the rest of the world in all these areas and I would disagree with Dr. Keyworth's statement that we can't possibly attempt, nor should we even try, to be a leader in all these areas at once, and I have a quote here to that effect. I disagree with that philosophy. How can we predict what will be best in the long-term for research and development?

I grant you we can't fund all of these areas. But we have to channel our efforts. Right now we are butchering those efforts on the basis of this year's budget and you can't just lay down that kind of scientific research and pick it up again next year and expect to go on where we were before. It will take years to recover what we are doing right now.

Thank you very much. The committee and other members may have questions to submit.

[A statement by Dr. George A. Keyworth II, Director, Office of Science and Technology Policy, submitted by Mr. Pewitt, follows:]

STATEMENT BY DR. GEORGE A KEYWORTH, II
DIRECTOR, OFFICE OF SCIENCE AND TECHNOLOGY POLICY
EXECUTIVE OFFICE OF THE PRESIDENT
SUBMITTED TO THE
SUBCOMMITTEE ON ENERGY, NUCLEAR PROLIFERATION
AND GOVERNMENT PROCESSES
OF THE
COMMITTEE ON GOVERNMENTAL AFFAIRS

MARCH 9, 1981

INTRODUCTION

The President's proposed FY 1983 budget to the Congress estimates Federal obligations for the conduct of Research and Development (R&D) of $43.0 billion, an increase of $4.2 billion over FY 1982. While most of this increase is for programs in the Department of Defense (DOD), significant increases are also proposed for R&D in the National Aeronautics and Space Administration (NASA), and the National Science Foundation (NSF). Obligations for basic research, about half of which is performed in the Nation's universities and colleges, are expected to increase by $473 million over FY 1982 to a total of $5.8 billion.

The Administration's proposals in FY 1983 for Federal support of R&D in general and basic research in particular reflect two very important things. First, these substantial increases, in a period of fiscal austerity, affirm the importance given to the role of science and technology in the achievement of our goals in the 1980's: enhanced national security; sustained, real economic growth; and improved quality of life for all citizens. They also affirm the importance attached to continued Federal support of fundamental research and to maintaining the vitality and health of the Nation's research enterprise.

Secondly, and of equal importance, these proposals flow from a new set of science and technology policies for the 1980's, policies which are responsive to the changed economic, national security, social and international environment and needs of the 1980's. Science and technology policy is not, cannot, and never has been made in a vacuum. It is properly shaped and informed by the economic, international and social environment in which it is formulated. While our policies for the 1980's are still emerging, the budget proposals to the Congress for FY 1983 represent a highly significant step in their evolution and implementation.

PRINCIPLES UNDERLYING SCIENCE AND TECHNOLOGY POLICY FOR THE 1980's

Priorities and Needs

As in previous years, the United States spent more money on research and development during 1981 and has more scientists and engineers engaged in these activities than any other industrialized democracy. Total national expenditures for all R&D activities were estimated to be about $69 billion. In 1982, the Nation is expected to invest $79 billion on R&D, an increase of 14 percent over 1981 and more than double the amount spent in 1975. Since 1975, in real terms, total private and public sector expenditures for R&D have increased an average of 4 percent annually. Clearly, the United States has a strong, broad science and technology base and its scientists and engineers in universities, private industry and the Federal laboratories carry out preeminent research in diverse fields ranging from high energy physics, agriculture, astronomy and biomedical sciences to such areas as microelectronics and communication optics.

Continuous growth in the amount of our national resources invested in R&D is not, however, an adequate principle for guiding national science and technology policy. It is misleading to assume that every additional dollar invested in R&D produces an equal increment of useful, quality output. Research and development, like other human activities, has a point of diminishing returns. Furthermore, using the principle of growth, as an end in itself, enables us to avoid hard choices in setting priorities.

There is an inevitable tendency, when resources are increasing, to add resources to all areas of research without discriminating between those areas which are more promising and those which have passed their peak. In these times when there are many competing demands on the Nation's resources and on the Federal budget, we can no longer afford the luxury of automatic growth.

Instead, the allocation of resources and the levels of support for R&D must be based on a careful examination of our national priorities. We must take a hard look at our needs in defense, in space, in the economy and in other areas and establish our research and development priorities in response to them. This is a critical step in insuring that the Nation realizes the largest return from its investment in R&D in a period of limited resources.

It is, of course, much more difficult to assess the returns from investment in basic research and to determine both what the proper level for that investment is as well as the appropriate balance among scientific fields. We know that it is vital to the future well-being and economic growth of the United States to maintain a broad base of support for diverse fields of science. While no one can foresee the exact nature of the problems or needs which this country will face tomorrow, we can be certain that basic scientific knowledge will establish the foundation for addressing them.

Because it is difficult, however, does not mean that we should not assess our priorities for the level and distribution of support for basic research and be prepared to make difficult choices. Frankly, we no longer have the luxury of avoiding these choices. Furthermore, the discipline of making such choices will ultimately benefit science since it forces us to ask whether or not we are using all of our resources to the best advantage.

This Administration can and will provide leadership in identifying the need to look, carefully, at how we allocate our resources in support of R&D and how we might best evaluate some of the benefits of research. The Office of Science and Technology Policy recently announced the formation of a White House Science Council which will meet periodically with the Science Advisor to give advice on specific issues in science and technology and to provide information on changing perspectives in the science and technology community. However, participation in these efforts must go well beyond the efforts of the Federal government. In particular, the scientific and engineering communities clearly have a special stake in and a special expertise for examining how we do, and should, allocate our resources for R&D.

Clarifying the Federal Role in R&D

A central principle underlying the Administration's science and technology policy for the 1980's is the need to clarify the distinction between public and private sector roles and responsibilities for the support and conduct of research and development. The Administration regards fundamental research as a vital investment that is likely to yield good returns for U.S. society. It believes that the primary responsibility of the Federal Government with respect to science and technology is to support long-term research. Since such research generally yields widely available information and knowledge, rather than specific products or processes, the incentives for strong support by private industry are lacking.

With respect to most technological development and demonstration projects, the Administration is committed to the view that the collective judgment of innovators, entrepreneurs and consumers, made in a free market environment, is generally superior to any form of centralized programming. Federal investments in technological development and demonstration projects will, therefore, be restricted to those few areas where the Federal Government itself is the principal consumer, as well as to a few potentially high-payoff areas in which the private sector is unable to invest because of the heavily regulated nature of the technology or because private firms cannot capture sufficient benefits from such investments.

The savings achieved by returning responsibilities for most development and demonstration projects to the private sector will allow the Federal Government to focus more clearly on its primary responsibility to support long-term research. By contributing to overall reductions in the Federal budget, these savings will also help to stimulate the economy and thus improve the overall climate in which all national activities, including scientific and technological activities, are conducted.

Industrial Research, Development and Innovation

The Federal government influences the direction and level of the national investment in science and technology directly through expenditures of public funds. However, the general economic and regulatory policies pursued by government influence most directly decisions of the private sector to invest in R&D. Thus, science and technology policy is inextricably related to economic and regulatory policies which affect the general availability of private resources for investments of any type as well as the willingness of the private sector to make more risky, long-term investments in research, technology and product innovation. Investment in R&D is investment in the future. In the past, uncertainties about future Federal policies with regard to taxes, patents, anti-trust interpretations, and regulatory requirements, as well as the high cost of capital and the general, prevailing economic environment, have acted as barriers inhibiting long-term industrial investments including investment in R&D. The Federal Government, by subsidizing certain development projects especially in energy production, has distorted the market and discouraged industrial investments. Termination of these economic subsidy programs will thus remove an important barrier to corporate investments in science and technology.

The Economic Recovery Tax Act of 1981 includes R&D tax credits, accelerated depreciation schedules and other incentives which, it is estimated, will stimulate an additional $3 billion in corporate R&D investments over the next five years. In addition, the Administration supports pending patent reform legislation that would extend to the entire private sector the right to retain patents developed under Federal R&D funding. This legislation would remove a major disincentive to the participation by industry in important national R&D efforts.

The Administration has also focused sharply on regulatory reform and has called for greater precision in assessing both the need for, and the potential impacts of, a broad class of Federal regulations as a means for encouraging greater industrial productivity.

Action, in this regard, reflects a widespread consensus that the Government overreacted during the 1970s--or reacted with inadequate information--in framing regulations designed to eliminate or minimize risks to health, safety and the environment. The President's Task Force on Regulatory Relief, chaired by the Vice-President, has initiated a comprehensive study of the entire set of regulatory laws and administrative procedures.

Regulatory reform will reduce the overall burden, to industry, of compliance with unnecessary and often uncertain regulations. Equally important, it will reduce the amount of defensive R&D that has been needed to operate in the past regulatory environment and has thus been diverted away from investment in more productive innovations.

CRITERIA FOR FEDERAL SUPPORT OF RESEARCH

Within these general principles, the Administration has adopted the following general set of guidelines for making the judgments reflected in the President's FY 1983 request to the Congress for R&D support:

- Though responsibility for most development projects will be returned to the private sector, there are a very few selected areas in which Federal support must necessarily continue throughout the research, development, demonstration and implementation stages. The most essential of these areas are those for which the Federal Government is itself the principal consumer of the results of research and development, or where R&D activities support essential Federal operating responsibilities. These areas include national defense, some components of the civil space program, and some aspects associated with civil transportation. Additionally, Federal involvement beyond the research stage is appropriate in a very few areas, such as in the nuclear industry, where the potential payoffs to the Nation are very large and the regulation of this industry is so extensive that effective private sector investment is prohibited. Other areas in which the Government has a more limited role to play include those of shared responsibility such as health and public safety, where the broad societal benefits justify Federal involvement.

- Because of the nature of basic research and the inherent uncertainty of its ultimate application or area of future need, wide-ranging support across fields and subfields of science will be maintained, thus providing the country with a capability to take advantage of important scientific and technological breakthroughs quickly and to respond to unanticipated needs.

- Research supported by Federal mission agencies will generally encompass both basic and applied research in disciplines appropriate to the execution of the respective agency mission.

- Since Government support of research in universities influences the Nation's ability to meet its future scientific and technological personnel requirements, these requirements and research support policy are interdependent and will be coordinated.

Within these general guidelines, the Administration has adopted stringent criteria to discriminate between the support of scientific areas that are the most promising and those that are less so. We intend to work closely with the scientific and engineering communities to translate these criteria into levels of Federal budget support. The key criteria used to determine the degree to which a scientific discipline, or project within a discipline, qualifies for Federal research support must be excellence in the investigators, excellence in the subject matter, and excellence in the expected results, as determined by the scientific and engineering communities themselves, working in cooperation with responsible Federal officials. An additional, important criterion for the public support of applied research whose aim is to provide the foundation for future technological advance must be pertinence—pertinence to the Nation's economic and social goals and needs.

Application of the pertinence criterion leads to a recognition that some areas of science and particularly of technology are more pertinent to the needs of other countries than to this country. U.S. science and technology is regarded as equal to or more advanced than any in the world in a wide range of fields, including high energy physics, agriculture, astronomy, geophysics, laser chemistry, biotechnology, and microelectronics. The Administration recognizes that maintenance of American pre-eminence in selected fields is an essential national goal.

An important reality of the 1980s is that many countries, the Western European nations and Japan in particular, have, with our help, reestablished the intellectual and productive capacities they lost during World War II. For this reason, undisputed world dominance in all fields of science and technology is not a viable goal to which U.S. national science and technology policy can aspire. American science benefits from healthy competition among scientists of all nations as long as an appropriate level of international cooperation is also maintained as a means for expanding the scope of the U.S. research effort. With constrained R&D budgets facing all nations, collaborative projects in areas of common interest such as energy, space, and transportation will surely become more attractive.

PROGRAMMATIC AND AGENCY THRUSTS IN THE FY 1983 BUDGET

In FY 1983, the Department of Defense will account for 57 percent of the R&D activities of the Federal government. Four other major supporters of R&D, the National Aeronautics and Space Administration, the Department of Commerce, the Department of Health and Human Services, and the National Science Foundation, account for an additional 37 percent of total Federal R&D activities. The remaining 6 percent is spread over more than 15 different agencies and programs.

Basic research in such fields as chemistry, physics, biology, earth sciences, materials and oceanography provides the underpinning for our Nation's future advances in health care, nutrition, and agriculture as well as the development of new technologies for defense, space and energy. The allocation of funds for basic research in the FY 1983 budget, which is increased by 9 percent over FY 1982, strengthens our efforts in space and defense. Special emphasis is also being given to the strengthening of basic research in the physical sciences and engineering as exemplified in the National Science Foundation and the proposed Energy Research and Technology Administration in the Department of Commerce. Research in engineering and the physical sciences is of special importance to long-term improvements in industrial productivity and economic growth.

Department of Defense

The Nation's supremacy in technology is a major source of its military strength. Thus the most essential function of the DOD and related Federal research and development programs is to provide the technological infrastructure which is so important to the steady, evolutionary growth of our military capability. The strategy is to employ science and technology to offset the growing quantitative disparity between employed U.S. military equipment and that of potential adversaries. Fundamental to this strategy is the fact that the United States leads in many of the basic technologies critical to our advanced weapons.

Obligations for the conduct of R&D by the Department of Defense will rise to $24.5 billion, an increase of $3.9 billion or 19 percent over FY 1982. This will provide increased support for research in areas such as very high speed integrated circuits, electromagnetic propulsion, carbon/carbon composite materials, artificial intelligence, aeronautics, and command, control and communication systems as well as R&D related to the development of advanced strategic systems such as bombers and ballistic missile defense.

National Aeronautics and Space Administration

The most important accomplishments of the Nation's space program during 1981 were the first two orbital flights of the Space Shuttle and the encounter of Voyager 2 with Saturn. Attainment of full operational status for the Shuttle will continue to be the principal objective of the Federal space program for the immediate future.

Data returned by space science missions continue to fuel the revolution in the way we think about the Sun, the planets, the stars, interstellar space and man's place in the universe. The second Voyager's observation of Saturn gave us unanticipated new facts about that planet. The Shuttle and spacelab are opening the door to a new era in space science. In addition to providing a capability for conducting human-monitored investigations, the Shuttle will be able to display, retrieve, repair or refurbish in orbit, and even return to Earth the space craft and experiments of missions such as the Space Telescope.

Obligations for the conduct of R&D by NASA will increase by 12 percent or $0.7 billion from FY 1982 to an estimated total of $6.5 billion in FY 1983. This increase will assure the timely transition of the Space Shuttle to an operational system. We share the concern that Shuttle effort not derogate from the exciting scientific programs of NASA. Thus, the Space Science program is proposed to increase by 20 percent over 1982 to a level of 682 in 1983. $~~602~~ million. This will provide for the continuation of the highest priority research and space exploration projects including further development of the Space Telescope, the Gamma-Ray Observatory and the Galileo Mission to Jupiter in 1985.

Department of Commerce

In FY 1983, the scope of R&D activities in the Department of Commerce will expand considerably as a result of the Administration's proposal to transfer the R&D programs of the Department of Energy to the Department of Commerce where they will be administered by the new Energy Research and Technology Administration (ERTA).

Support will be provided by ERTA for the development and testing of nuclear weapons including the development of improved technologies for maintaining nuclear weapons treaties and for safeguarding and disposing of waste from special nuclear materials production. ERTA's general research and science program focuses on work in high energy and nuclear physics. The administration is fully committed to maintaining U.S. leadership in these areas. ERTA's program in basic energy science in such fields as nuclear science, materials science, engineering and mathematics is intended to strengthen the scientific and technical base for future advances in all energy technologies.

Overall, obligations for the conduct of R&D by ERTA will decrease by 13 percent or $0.6 billion from FY 1982 to an estimated total of $3.9 billion in FY 1983. These decreases reflect the proposed curtailment of Federal support for near term applied research and for development projects, (e.g., solar hot water heaters and windmills) consistent with the principle spelled out earlier that such activities are more appropriately carried out by the private sector. However, consistent with our overall science and technology policy, the basic research programs of ERTA will increase by 14 per cent over 1982 to a level of $741 million in 1983.

The other major, ongoing R&D activities in the Department of Commerce are focused in the National Oceanic and Atmospheric Administration (NOAA) and the National Bureau of Standards (NBS). In both cases, obligations for R&D will decline in FY 1983, reflecting primarily either the transfer of activities to other agencies or the terminations of work more appropriately conducted by the private sector.

The NOAA, for example, is responsible for managing the Federal remote sensing space system after it progresses from developmental to operational systems. During the past year, the Department of Commerce developed a pricing proposal for Landsat-D products and services designed to recoup, starting in 1983, that system's operating costs. It has also established a group to help it plan for the eventual transfer of Landsat-D's operation to the private sector.

Health and Human Services

Recent years have witnessed a striking increase in basic knowledge of living things. It is generally acknowledged that the flood of basic discoveries in areas like genetics, biochemistry, and physiology constitute a 'revolution in biology' and have laid the groundwork for advances in the Nation's capabilities for prevention, diagnosis, and treatment of disease. Beyond fundamental knowledge development, a key Federal concern is the application of health research findings to health care service situations.

Obligations for the conduct of R&D in the Department of Health and Human Services are estimated to total $4.1 billion in FY 1983, an increase of $150 million over FY 1982. Most of the R&D activities in HHS are concentrated in the National Institutes of Health (NIH) which will receive $3.5 billion or 85 percent of the total in FY 1983. This funding will continue the strong national effort in biomedical research including such things as:

- Basic research on fundamental life processes;
- Clinical research designed to transfer and apply the results of basic science to health treatment;
- Targeted research in epidemiology and risk estimation; and
- Basic and clinical research into the cause and prevention of diabetes.

National Science Foundation

While no one can foresee the exact nature of the problems or needs which this country will face tomorrow, we can be certain that basic scientific and engineering knowledge will lay the groundwork for addressing them. Just as past national investment in research has produced a U.S. science and engineering capability that is preeminent in a broad range of fields, so today's investments will maintain and build on these strengths to provide a strong foundation for the Nation's future economic and social well-being.

The National Science Foundation's role in helping to realize these national goals is to provide the tools and support needed to continue building the base of knowledge and experience on which innovators and managers can draw in the future. It accomplishes this primarily through the continuing, selective support of high quality, fundamental research in a broad variety of scientific and engineering disciplines. In FY 1981, it accounted for almost one-fifth of the total Federal support of basic research.

Most of this work is carried out in the Nation's universities and colleges where it is related, directly, to the education of new generations of scientists and engineers. In FY 1983 it is estimated that support will be provided to over 9,000 graduate students through their participation on NSF research projects. In addition, the prestigious NSF Graduate Fellowship program, which selects its recipients through national competition across all fields of science and engineering, will support an additional 1,400 students in FY 1983.

Obligations for the conduct of R&D by the National Science Foundation are estimated to total $1.03 billion in FY 1983, an increase of $72 million or 7.5 percent over FY 1982. In developing this request, a broad base of support across all disciplines was maintained with special emphasis on such areas as computer science, earth science, electrical and computer engineering, and chemical process engineering. In keeping with the Administration's specific emphasis an excellence and pertinence in establishing funding priorities, these were the areas thought to be most ripe for major advances in basic understanding and most pertinent to the future growth of the Nation's economic and production base.

SOME KEY ISSUES FOR THE 1980's

There are several important issues related to the Administration's development of science and technologies for the 1980's which cut across the programmatic and agency activities described earlier. They have several things in common.

First, the Federal Government has a legitimate and significant role in them. However, it is not the only significant actor nor even, necessarily, the most important one. These issues will require the participation of many groups--private industry, State and local governments, professional and scientific associations -- in order to develop a consensus about the strategies which must be followed if they are to be adequately addressed. Secondly, these issues bear on the infrastructure of our Nation's science and technology base and on the way in which we allocate our resources now, and in the future, for research and development and for the training of new generations of scientists and engineers.

These issues are:

- Engineering Education
- Pre-College Science and Mathematics Education
- Scientific Research Instrumentation Obsolescence
- International Cooperation in Scientific Research

Engineering Education

The increased demand for engineers in recent years, particularly in the electronics and engineering industries, has forced up entry level salaries and also caused college enrollments in engineering to rise. Both of these factors have placed a strain on the Nation's schools of engineering. The first makes faculty salaries and graduate student stipends increasingly less competitive with industry, leading to documented shortages in faculty and a decreased number of doctoral candidates. The second increases the demand for faculty, making the problem of shortages even greater.

These trends, if uncorrected, could have several negative consequences. They could degrade the quality of engineering education in the U.S. Further, declining PhD. enrollments, faculty vacancies, and obsolete research instruments constitute barriers to academic research in engineering. Such research is the base from which much of our future industrial development and innovations will come. Finally, the armed services-which also cannot offer competitive salaries - continue to experience difficulties in recruiting scientists and engineers into the military and in hiring civilians for in-house defense laboratories.

There is evidence that some academic institutions are beginning to respond to this problem by differentially raising the salaries of engineering faculty, following a practice traditionally used with the faculty of other professional schools. Where done, this may make salaries more competitive with those in industry. There is also evidence that private industry is recognizing that it has an important stake in responding to these developments. The question of engineering research equipment obsolescence is important as it affects the attractiveness of academic careers. Here, too, there are opportunities for universities as well as the private sector to consider possible mechanisms for upgrading the quality of such equipment.

To a large extent the market for science and engineering personnel is acting as it should. Undergraduate engineering enrollments continue to increase as qualified secondary school students respond to their perceptions of attractive career opportunities, with the result that increasing numbers of the new engineers required by industry are graduated each year. However, limited Federal action may be necessary as a catalyst where market responses are slow, or where the problems are particularly difficult for the private sector to solve.

A good deal of Federal support for the education of science and engineering personnel will derive from grant and contract support for research to universities. In addition, the Government is providing limited, targeted support to help solve the engineering graduate student and faculty problem. For example, the National Science Foundation has initiated a special new engineering faculty research incentive program designed to attract high quality new PhD engineers into academic careers. Also, the Department of Defense has increased both the number of graduate fellowships offered in engineering and science and the amount of each stipend in order to make full-time graduate study a more attractive option.

Pre-College Science and Mathematics

The decreasing emphasis on science and mathematics in the U.S. public schools contrasts sharply with the situation in other industrialized countries where deliberate attempts are being made to attain high levels of technical competency among the general population. In Japan, about 25 percent of classroom time between grades 7 to 9 is devoted to science and mathematics; nearly all college-bound students take these natural science courses and four mathematics courses in high school. The general preparation in West Germany is similar.

In the U.S. only about one-sixth of the high school students currently take both science and mathematics courses. There has been a national trend toward reduced high school enrollments in these areas coupled with less stringent graduation requirements. In response, college admission requirements in science and mathematics have been reduced. According to a 1981 survey, fully 22 percent of high school mathematics teaching positions were vacant, and officials in 16 states characterized the situation as "critical."

Diversity and adaptability to changing circumstances have been hallmarks of the U.S. educational system. Local communities, in concert with industry and professional groups, will have to decide how best to allocate resources in order to emphasize excellence in all educational endeavors, including instruction in science and mathematics, to assure the future vigor of their own regions and the Nation as a whole. Universities must decide whether their goal will be to protect excellence by a more selective distribution of resources, or to spread those resources ever wider and thinner. In the case of publicly supported universities, state governments will have to decide whether resources will continue to be allocated on a student credit hour basis, and thus to be driven solely by undergraduate enrollments, or on the basis of a long-range review of the universities' role in the state and Nation.

Much of what should be done has already been started. Whether still more attention and resources will be devoted to sustaining the quality of U.S. science and engineering education depends in large measure on public perceptions of the importance, to the Nation, of maintaining both scientific and technological leadership on an international basis, and on a better understanding of the central importance of scientific and technological activities--and science and technology literacy--to our national needs and goals.

At the Federal level, two significant steps are being taken to call attention to the importance of this issue and to provide a further catalyst for defining a national--not necessarily Federal--response.

The Secretary of Education established, in August, 1981, a National Commission on Excellence in Education comprised of school, college, and university educators, state and local officials, and leaders in a range of professions. This Commission, which includes a panel on science and mathematics, is conducting an eighteen-month study and will make recommendations for action at all levels of government aimed at restoring excellence throughout the U.S.educational system. In addition, the National Science Board is establishing a Commission on Pre-college Education in Mathematics, Science, and Technology. This Commission will work with many national and local scientific, educational, professional, industrial and governmental groups to clarify needs and opportunities in pre-college science and mathematics education.

Obsolescence of Scientific Research Instrumentation

Instrumentation is at the heart of experimental research. Modern instruments with qualitatively superior capacities for analysis and measurement can open up whole new fields of scientific inquiry, and can greatly reduce the time necessary to carry out research projects. Access to such advanced scientific instrumentation determines in large measure whether scientists can participate in forefront research.

There is currently concern within the Administration and among leaders of the scientific community that many instruments in the cost range of $100,000 to $1 million at U.S. research universities are rapidly becoming obsolete. As a result of increasing costs due mainly to inflation and the increasing sophistication of instruments required to do frontier research and decreasing sources of funds, these instruments will be difficult to replace with the state-of-the-art equipment necessary to ensure the progress of the scientific research required to fulfill national needs.

The growing obsolescence of research instrumentation in U.S. universities is a problem not just for the universities themselves, but for the Nation as a whole. To the extent that such obsolescence impedes the progress of fundamental research at the university, its effects will be felt in such critical areas of application to the Nation as agriculture, medicine, biotechnology, engineering, energy, and national defense. Since over half the basic research performed in the United States is carried out at universities, a decline in the research potential of these universities could result in a significant decline in the general rate of this Nation's scientific advancement and ultimately its technological innovativeness.

The magnitude of the scientific instrumentation obsolescence problem and the potentially negative impacts this problem can have on national objectives such as economic revitalization and productivity make it an area of special concern for the Federal Government. A special Interagency Working Group on University Research Instrumentation, managed by the National Science Foundation, has been established to assess the status of research instrumentation and facilities at universities and to design means for encouraging private and public sector support for their modernization. The Department of Defense is proposing a $30 million university research equipment program as part of its FY 1983 budget request to the Congress. Support for research instrumentation will increase by 11.5 percent or $9.8 million to a total of $95.3 million over FY 1982 in the FY 1983 request of the National Science Foundation.

In addition, other less direct actions have been taken to ameliorate the instrumentation problem. For example, The Economic Recovery Tax Act of 1981 contains tax incentives for industrial equipment contributions to academic institutions. While the relationships between universities and corporations are voluntary in nature, the Federal government can play an indirect role in influencing the conditions under which such linkages develop.

In the final analysis, however, universities themselves must assume the major share of responsibility for dealing with the instrumentation problem. They need to take the initiative in seeking cooperation from industry and to propose more flexible Federal funding mechanisms. Most importantly, they need to optimize their internal allocation of resources to achieve the appropriate balance between operating funds and equipment. Proposed Federal funding for university research is increasing in real terms, and instrumentation must be considered within that funding context, not as an addition to it.

International Cooperation in Science and Technology

One of the realities of the 1980s is that whereas the United States retains international preeminence in many areas across the entire spectrum of science and technology, we no longer retain the position of undisputed dominance in virtually all fields. Nor do we hold a monopoly on the world's scientific and engineering talent. The Western European nations and Japan have reestablished the intellectual and productive capacities they lost during World War II, and several less developed countries have built their own capabilities for carrying out scientific and technological activities in selected areas of special concern to them. Thus, world domination of all areas of science and technology is no longer a viable goal to which the United States--or any other nation--can aspire. The U.S. can benefit from the healthy competition, as well as cooperation, among scientists of all nations and must be prepared to meet the challenge of making the best possible use of resources abroad to help ensure continued progress in science and technology in the United States.

International cooperation should not be synonymous with Federally-sponsored cooperation. American scientists and engineers cooperate in a great many cooperative international ventures--often through their universities or the industrial firms that employ them--in which the Federal Government acts, at most, as a facilitator. An important aspect of the Administration's science and technology policy is to encourage such private sector cooperation. It recognizes the unparalled contribution made by U.S. universities to the development of science abroad. It also recognizes that international cooperation among industrial firms in areas such as transportation, space commercialization, communications, and energy production can serve important U.S. national interests, as well as the interests of the firms involved. Indeed, new forms of private, multinational arrangements may well be needed to develop and commercialize very expensive future technologies--in space and energy--that can benefit many countries, including our own.

In the past, U.S. firms have often been hampered in international trade in some high technology areas, particularly chemicals and pharmaceuticals, by a welter of domestic regulations. This may in turn have prevented them from realizing the full potential benefits of international cooperation in science and technology. The principle, delineated earlier, of reducing or eliminating unnecessary regulations and other similar controls on U.S. industry should therefore improve prospects for international industral cooperation, even as it stimulates more domestic private sector investments in long-range R&D.

CONCLUSIONS

Progress in science and technology has become an imperative for all modern industrial societies, and the United States is continuing both to strengthen its broad scientific and technological capabilities and to apply these capabilities to help define and resolve a wide range of issues that concern the Nation. Since the end of World War II, and especially since Sputnik, the Federal government has played a major role in sustaining and building the Nation's basic scientific, engineering and technological strengths and in drawing on these strengths to support the accomplishment of Federal responsibilities in defense, space, health, agriculture and other areas.

In FY 1983, the Administration is requesting a total of $43.0 billion for R&D, an increase of 11 percent over FY 1982 and an indication of the continuing importance of R&D to the present and future health and strength of the Nation.

Of equal importance, this request represents the results of applying a new set of principles in the development of Federal science and technology policies for the 1980's:

- Growth in R&D support, alone, is no longer satisfactory as a guiding principle in resource allocation. Resource allocation must be based on a careful assessment of priorities and needs and on making hard choices based on an assessment of the quality and pertinence of alternative R&D investments.

- Economic policy and regulatory policy are a vital part of national science and technology policy. Taken together, they influence the availability of resources for private investment in R&D and the willingness of individuals and industry to take the long-term risks inherent in such investments. This Administration is committed to expanding the role of the private sector in R&D through its economic and regulatory policies.

- There must be a clearer delineation between the Federal and the private role in R&D. Only those activities directly related to Federal responsibility should be supported by the Government.

- Finally, there will continue to be a strong Federal presence in the support of basic research.

Several major, cross-cutting issues have been identified which clearly affect the present and future capabilities of the Nation's science and engineering base: the adequacy of education in engineering; the declining level and quality of pre-college education in mathematics and science; the growing obsolescence of scientific research instrumentation; the need for and challenges in international cooperation in science and technology. The Federal role in each of these areas varies, though it is important in all. In the end, however, there are challenges in each of them to the other major institutions of our Nation. Our future may depend very much on how well we, as a society, are able to respond.

Senator GLENN. Our next witness will be Dr. William Carey, executive officer of the American Association for the Advancement of Science. And part of his testimony will be to give us this morning the AAAS "early bird" analysis of the President's budget for R. & D. The early bird analysis is a cooperative exercise that involves some 16 professional scientific, technological, and educational societies.

Dr. Carey, we are glad to have you here this morning.

TESTIMONY OF WILLIAM D. CAREY, EXECUTIVE OFFICER, AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Mr. CAREY. I will not attempt to summarize the early bird analysis but I have brought it and we will leave it for the committee's use.

Senator GLENN. We appreciate that. We will make that part of the record or a summary thereof.

Mr. CAREY. There is a summary of the early bird analysis attached to my statement, Senator, which may serve the initial purposes.

The point about budgets isn't so much the arithmetic which always turns out differently in the end, but the policy intentions that ground the budget. And that is what you have been talking about all morning.

These policy intentions, as we know, do not treat research and development in isolation, but rather in the whole context of the administration's social, economic, and political calculus. There is nothing new about this. Administrations have been doing this as far back as I go.

So, research and development is not an independent claimant for resources, it is a subordinated requirement of agency missions. That is the way it is done. I think that is logical even though it does result in spasms and discontinuities in the year-to-year profile of the research and development budget.

The 1983 budget seen from the point of view of R. & D. reflects traits inherited from its predecessors, particularly the 1982 budget. The same policy intentions, the same working assumptions are in evidence and everything seems to be going as planned. Defense, which went up very sharply in 1982, goes up sharply again. Social programs cut in 1982 are cut again. And yet research and development in the aggregate has done better than most areas in the budget, thanks to the defense buildup and what I take to be a deliberate and purposeful enhancement of basic scientific research.

Of course, you can't get away from the numbers and when you look at them they tell us different stories depending on whether we are using inflationary dollars or constant dollars. In inflationary dollars, to begin with, the budget would take total R. & D. up very sharply from $37.3 billion in 1981—note that I am using 1981—to $44.4 billion in 1983. And that over the 2 years is a percentage increase of 18.9 percent. That is a very impressive growth for a 2-year period.

Now, the reason I am going from 1981 to 1983 is that the 1982 numbers are not reliable. There have been a lot of adjustments in those 1982 numbers and a couple of big agencies are still living under a continuing resolution, so we are not quite sure of the 1982 number base. So I am comparing 1981 and 1983. I think it is really more informative.

I have said there is a percentage in inflationary dollars of 18.9 percent for R. & D. over that 2-year period. When you turn it around to constant dollars, what you find is that the real increase from 1981 to 1983 is only 2.2 percent.

When you go inside the aggregate trend, it is very clear that there is a massive reorientation taking place in the structure of the R. & D. budget. You see this when you compare defense-related R. & D. investment with non-defense-related R. & D. Again, between 1981 and 1983, defense connected R. & D. is up 22.5 percent, non-defense R. & D. is down by 18.9 percent, using constant dollars. And the policy question is whether this intentional and planned disparity is going to continue to widen when we get to the 1984 budget, into the 1985 budget and what effects that would have on the scale and vitality of civil R. & D. in the Nation's economy, especially if industry does not replace Government's R. & D. dollars with its own.

Now, the administration's position, as we have heard, is that the Government ought to get out of civil R. & D. business and leave it to the private sector within a federally provided climate, while encouraging innovation through a climate to be created by reduction in Federal spending, regulation, and taxes. So, what we find is that research and development policy is a derivative of economic policy. If we expect the economic policy to work, maybe the R. & D. policy will work. But if it doesn't, then civil R. & D. has been left stranded in the budget without the dollars, and it won't be an easy thing to get the toothpaste back into the tube in the future when you look at the magnitudes that we are talking about of R. & D. cuts in current dollars in civil agencies, and we have heard a lot about them in energy this morning: EPA has been cut 44.5 percent, Commerce 30 percent, Labor 91 percent, HUD cut 47.4 percent, and so forth. And the problem we have is that the intended substitution of private industry dollars for Federal dollars does not occur in a timely way and in the absence of a staged transition, to make a policy that works, and in the absence of a healthy national economy, the work simply goes down the drain and the whole system is traumatized. There is something here to be learned that is relevent to the current prescriptions for a New Federalism, but that is off the point.

I am glad to see that some special treatment has been given in the budget for basic scientific research. Maybe not enough. Never enough. But the figures tell us that there is an average of 12 percent increase in basic research in civil agencies in current dollars over the 2-year period, 1981 to 1983, and a 36-percent increase in DOD basic research over 2 years.

Now, while the increase in civil basic research unhappily turns into a decline after inflation is figured in, I still think it is significant that at least in budget dollars the administration has kept some forward motion in this area.

Looking at the whole budget for R. & D., all R. & D. dollars, I can't find it in me to quarrel too much with a total number of $44.4 billion considering the deficits we have. If you just look at it in terms of current dollars, it is a new high and it will probably go higher in 1984 and 1985. The argument is not, as far as I am concerned, with the size of the R. & D. allowance total, but with its mix and its judgment calls. I will make some very brief comments about those.

If you want to know whether I consider the budget sufficient to get us moving to where we ought to be as the leading country in scientific progress and technological innovation, I say it falls well short.

I do not expect benefits to trickle down from defense R. & D. into the civil economy and turn that economy around. I think that instead of drawing ideological lines between what is public sector R. & D. and what is private sector R. & D., we should be sharing capital and risks as partners to stimulate modernization and productivity and innovation. I think that instead of abandoning the national interest in a scientifically educated and literate school population, the Government ought to recognize the disaster in education for what it is and get into it strongly. And I think, finally, that the Government's present itch to throw a blanket of censorship and classification over research that is not related to the national security is misguided and counterproductive both to good science and, in the end, to national security.

Senator, those are my opening remarks. I will be glad to try to answer questions.

Senator GLENN. Thank you very much, Mr. Carey.

In this area of education that you mentioned—in engineering education, manpower needs, university needs—I think we have a major problem in that area if we are to have the people available to do this kind of work in the future.

Would you care to expand on that a little bit, your comments on those areas of manpower and technological training?

Mr. CAREY. It seems to me, Senator, if we are headed for a major buildup in our national security efforts, defense programs, we are going to need the trained manpower and womanpower to deal with them. It is a very sophisticated business that we are going to be into. We are not throwing rocks and spears. And what troubles me very much is that when we use the expression "the technology base of the United States," we never factor into that base the human resources that are so critical to it.

There is a blind side in the way we estimate and measure our technological base and our capacity, and the blind side is the human resources side. And I don't see anything encouraging at all in the budgets, not just from the last couple of years but the budgets that preceded the last couple of years. This has been going on, Senator, for a long time, and it is very discouraging. The decisions that were made partially by Mr. Carter and then emphatically by President Reagan to cripple and then eliminate the science education programs of the National Science Foundation are particularly troubling. Not that there ever was the kind of Federal dollar investment in science education that there should have been, but there was something. There was at least an acceptance of a national interest factor, and the national interest factor is one that we don't hear about any longer. That is what is so shocking, and I am very pessimistic as a result.

We can throw a lot of R. & D. dollars into the system, but when those R. & D. dollars outrun your human resources, they are not going to be productive R. & D. dollars.

Senator GLENN. The administration apparently views investment in basic research as a Federal responsibility, but one that must be shared by the private sector. And I don't disagree with that, but to the extent we see the budgets being cut or maintained at existing levels, can it really be, in your opinion, expected that the private sector will replace anything other than a small fraction of the Federal funding for basic research as contrasted with more applied marketable research?

Mr. Carey. No; I don't expect that the private sector will substitute its dollars for Federal dollars in the area of basic research. They have not been doing that for quite a long time, Senator, and under present economic conditions and incentives and disincentives they are not going to start now.

Senator Glenn. Many foreign governments provide direct support to industry for development and demonstration of new technologies to improve efficiency and productivity. That has been true for electronics, energy-efficient devices, and so on. The administration is now proposing to essentially eliminate all Federal support for near-term industrial technology development work. I know this is a grey area here, how far the Government goes. I pushed very hard, as far as I can, to try and keep work going in those very basic areas that can be exploited by industry and business. That has been the history of the country and I don't think it is less excusable now than it has been in the past.

Would you comment on that? Where do you draw the line?

Mr. Carey. It is very hard to draw it explicitly. For some years, Mr. Chairman, I served as the outsider on the Statutory Visiting Committee of the National Bureau of Standards, in fact chaired it my last year, and they were very proud at that point at the National Bureau of Standards of the number of programs that were called productivity and innovation initiatives, including robotics, automation, semiconductor work. In the field of standards and measurement materials this was work of some considerable importance.

I have been shocked to find out that under the ideological framework that we hear about, NBS had been pushed out of those areas.

When NBS gets into areas like these, it does so with private industry cheering its head off because there is nobody else that is going to do these things, and they are critical to steering innovation and technology into productive directions.

This is why I can't give you a categorical answer to where the line is drawn, but when you look at particular things of this kind, when you look at the importance of the manufacturing industry, for example the computer industry, if you will, and at the modest work of the National Bureau of Standards, it is impartial and very important. We all gain and the national interest gains. Then all of it is turned off and there is something awfully peculiar about the way the decisions are made.

I have also been serving recently on a subpanel of the Energy Research Board which has been trying to rationalize the problems of the multiprogram national laboratories and I am familiar with the numbers and the decline and the erosion and the trauma that exists in most of those laboratories. And it isn't helped by the terminal state on the Department itself in terms of being scheduled for abolition.

Now, this panel that I am on is a mixed panel, academic, industrial, and government, and we get into some arguments.

My own position about those laboratories is that they again are a very central part of the U.S. technology base.

Senator Glenn. And one of the least appreciated by most people.

Mr. Carey. Absolutely. And to see those institutions stumble, to see that they have no confidence in their own planning as to where they stand in the asset calculation of U.S. Government, after all these years, to me is almost unbelievable.

Now, again it is hard to draw a clear line that answers your question as to where it is private and where it is government and what you should do. I think that we ought to start really pursuing that question.

As I said in my statement here this morning, I think that we spend too much time drawing chalk lines while our competitors in the world are doing something different and what we should be doing is working out combinations of responsibilities and resources and assets. If we began to think more of how government and the private sector could share capital and risk in getting on with the things that we ought to be getting on with, I think it would be much more profitable for us, Senator, but nobody in the administration is going to listen to that.

Senator GLENN. I couldn't agree with you more. I think we need to do more cooperative work back and forth.

In this statement I entered in the record in its entirety I had some figures on the national labs. In Argonne where they are involved in energy and environmental research, 600 positions already have been cut. The laboratory's director says that an additional 600 may have to be laid off. At Brookhaven National Laboratory, 270 of 3,600 employees have been laid off and they may have to cut 25 percent of the work force within the year. At Fermi National Accelerator Laboratory, the staff was trimmed by 200 people after the March budget projections, about 12 percent of the staff. The laboratory's Deputy Director has been quoted as saying that an additional 200 to 300 people may be let go in a worst-case situation. NASA-Lewis in Cleveland I mentioned, a center which employs 2,700 persons, which has dwindled down through the years not just in this administration, but some years ago employed 5,500 more than 200 full-time equivalent slots are scheduled to be axed in 1983. JPL at Pasadena has ended up having such cutbacks in the planetary program at NASA that its best people will inevitably start drifting away.

John McCarthy, head of the NASA-Lewis Laboratory put it this way:

> It is time that this country came to its senses and supported the vital research and technology necessary for national economic health. Cyclical inadequate funding is the road to disaster.

I think he is absolutely right. I would add, Dr. John McCarthy resigned a few days ago. I think that is tragic. I don't know how much of it was a legitimate retirement move and how much of it was utter frustration over what he is faced with there. I can't say for sure, but I think it was probably the latter than the former.

Mr. CAREY. I think one of the problems is, too, Senator, that when these cuts are made, and slots are eliminated, it is nice to talk in terms of slots because slots don't walk around, they are just spaces, but when you look at who the people are who are being dropped, for the most part the ax first hits the younger scientists, younger researchers, technicians, they go first, and then you work your way through the system and pretty soon after about the second or third wave of cuts you find that the human resource investment on which you have counted as a laboratory director for the next 10 years, the bright, creative people and so forth, are the first to have gone, and that is very poor investment philosophy.

When you then look at what we are hearing these days in terms of putting security classifications over basic research, I just feel that we are taking steps in this country with the best of intentions, economic reasons, national security reasons, but we are going to be short-circuiting our future.

Senator GLENN. I agree.

Mr. CAREY. I am very much troubled.

Senator GLENN. I agree very much. I am told by staff that Dr. McCarthy is not retiring, he is going to MIT from whence he came and he was on leave while heading the NASA-Lewis Laboratory.

Mr. CAREY. That is paradise up there.

Senator GLENN. I hope you treat him well when he gets back up there. I don't know that if he had not had some of the difficulty out there he might still be willing to stay on because he has been a good director there. I know he was very frustrated at the number of projects that had been terminated and it is a shame we have to lose him from NASA-Lewis Lab.

Mr. Carey, we appreciate this very much.

[The prepared statement of Mr. Carey, with attachment, follows:]

Testimony of

William D. Carey
Executive Officer
American Association for the Advancement of Science

Subcommittee on Energy, Nuclear Proliferation and Government Processes

March 9, 1982

Mr. Chairman and Members of the Subcommittee:

I appreciate your invitation to share with you my perspectives on scientific research and development in the United States.

For the past several years, the AAAS has followed closely the funding decisions of the President and the outcomes of Congressional action, and the Budget for fiscal 1983 is no exception. I will submit for the hearing record, with your permission, a copy of our Intersociety Preliminary Analysis of R&D in the FY 1983 Budget, which is more conveniently referred to as the "Early Bird" analysis; the "overview" chapter of this report is attached to this statement. Each year this report is prepared as a joint effort by some 16 scientific, engineering. and higher education societies, whose names are found on the cover of the report. By June, the AAAS will have completed and published a more thorough descriptive and analytic report. This report will be used as the basis for our annual Colloquium on R&D Budgets and Policies.

The point about budgets, of course, is not so much the arithmetic they display (because that always turns out differently when all is said and done) but the policy intentions that ground the budget and make it the decision-forcing tool that it is. These policy intentions, as we know, do not treat R&D funding in isolation but in the whole context of the administration's social, economic, and political calculus. There is nothing new about this. R&D is not an independent claimant for resources, but a subordinated requirement of discrete agency missions. I think this is logical even though it leads to spasms and discontinuities in the year-to-year budget profile of R&D.

As we see the 1983 budget from the viewpoint of R&D, it reflects the traits inherited from its predecessor, the 1982 budget. The same policy intentions and working assumptions are in evidence and everything seems to be going according to plan. Defense, which rose steeply in 1982, rises still more in 1983. Social programs cut in 1982 are cut once again. But R&D has done better than most areas in the budget, thanks to the defense buildup and what I take to be a deliberate and purposeful enhancement of basic scientific research.

We can't get away from the numbers, of course, and they are worth a brief comment. The numbers tell different stories, depending on whether we are quoting inflationary dollars or constant dollars. In inflationary dollars, the budget would take R&D up sharply from $37.3 billion in 1981 to $44.4 billion in 1983, a percentage increase of 18.9 percent, which is undeniably impressive growth for this two-year period. (Parenthetically, I should note that because of the many major adjustments in the FY 1982 budget and because two major R&D agencies are still funded through a continuing resolution, FY 1982 may not be a reliable benchmark for budget trends, so I will speak mainly of two-year budget changes, from FY 1981 to FY 1983.) In any case, converting to constant dollars, we find that the real increase from 1981 to 1983 is only 2.2 percent.

Looking inside this aggregate trend, it's clear that there is a massive reorientation taking place in the structure of the Federal R&D budget. We can see this in comparing defense-related R&D investment with non-defense R&D. Between 1981 and 1983, defense-related R&D is up by 22.5 percent, while non-defense R&D is down by 18.9 percent, again using constant dollars. The policy question that this poses, of course, is whether this planned disparity will continue to widen in the 1984 and 1985 budgets and what effects it would have on the scale and vitality of civil R&D in the nation's economy, particularly if industry does not replace government's R&D dollars with corporate dollars.

The administration's position, as we know, is that the Federal government ought to get out of the civil R&D business and leave it to the private sector within a Federally-provided climate that encourages technological innovation -- a climate created by reduced Federal spending, regulation, and taxes. In this respect, R&D policy is derived from the administration's economic policy. If we expect the economic policy to work, then perhaps the R&D policy will work out too. But if it doesn't, then civil R&D has been left stranded in the budget without dollars. It will not be an easy matter to get this toothpaste back into the tube in future years, when you consider the magnitudes of the R&D cuts (FY 1981-83) in current dollars in civil agencies: Energy cut 21.7 percent; EPA cut 44.5 percent; Commerce cut 30.2 percent; Labor cut 91.0 percent; and HUD cut 47.4 percent. The problem is that the intended substitution of non-Federal for Federal funds does not occur in a timely way, and in the absence of a staged transition (to say nothing of a healthy national economy) the work simply goes down the drain and the whole system is traumatized. There is, incidentally, a lesson here that is not irrevelant to the current prescriptions for a New Federalism.

I am glad to see that a degree of special treatment has been accorded basic scientific research in the FY 1983 Budget. The statistics indicate that there is an average 12 percent increase in basic research sponsored by civil agencies in current dollars between FY 1981 and FY 1983, as well as a 36 percent increase in Department of Defense basic research (again in current dollars over two years). While the increase in civil basic research turns into a small decline after inflation is taken into account, it is significant that in budget dollars the administration has maintained some forward motion in this vital area.

Taking the budget as a whole, I can't fault a number for total R&D of $44.4 billion, considering the deficits we are facing. In current dollars, it is a new high and it will probably be even higher in 1984 and 1985. The argument is not with the size of the R&D allowance but with its mix and its judgment calls. If you ask whether I consider the budget adequate to get us moving up to where we should be as the leading nation in scientific progress and technological innovation, my opinion is that it falls well short.

I do not expect benefits to trickle down from defense R&D into the civil economy to any appreciable extent. I think that instead of drawing ideological lines between public sector R&D and the private sector, we should be sharing capital and risks as partners to stimulate modernization, productivity, and innovation. I think that instead of abandoning the national interest in a scientifically educated and literate school population the Federal government should recognize the disaster in education for what it is, and get into it with both feet. I think that government's present itch to throw a blanket of censorship and classification over scientific research that isn't clearly related to national security is misguided and counterproductive both to good science and to our national security.

This concludes my remarks, Mr. Chairman. I hope that they have been responsive.

ADVANCE COPY

EXCERPT FROM:

Intersociety Preliminary Analyses of R&D In the FY 1983 Budget

American Association for the Advancement of Science

American Anthropological Association

American Astronomical Society

American Chemical Society

American Educational Research Association

American Institute of Aeronautics and Astronautics

American Institute of Biological Sciences

American Institute of Chemical Engineers

American Meteorological Society

American Physical Society

American Psychological Association

American Society of Mechanical Engineers

Association of American Universities

Conference Board of the Mathematical Sciences

Institute of Electrical and Electronics Engineers

National Association of State Universities and Land-Grant Colleges

March 1982

R&D IN THE FY 1983 BUDGET: AN OVERVIEW

American Association for the Advancement of Science
Albert H. Teich
Jill P. Weinberg

This chapter provides a preliminary overview of the major trends and developments in the Reagan Administration's proposed FY 1983 budget. It describes briefly the key elements of federal policy affecting R&D, then presents aggregate statistics on R&D and its relation to the total federal budget. Details of agency R&D budgets and cross-cuts for a number of major scientific and engineering disciplines will be found in succeeding chapters in this report.

The information on which this chapter is based is drawn mainly from "Special Analysis K" of the FY 1983 Federal Budget (published by the Office of Management and Budget--OMB--in February) and on back-up data associated with the special analysis. A more in-depth treatment of R&D in the FY 1983 budget will be found in Research and Development: AAAS Report VII, to be published by AAAS in June 1982.[1]

Several characteristics of this analysis should be noted:

(1) Inflation Assumptions

In order to account for the effects of inflation, budget trends are often expressed in constant (real) dollars using appropriate deflators. The authors have used deflators consistent with the economic assumptions on which the FY 1983 budget is based. These assumptions are controversial, and there are many uncertainties as to the course of the economy over the next several months and on into FY 1983. There is, therefore, a wide margin of error in the constant dollar trends presented here and in other budget analyses. Relatively small changes in these assumptions can make the difference between projected "real growth" and "real decline."

(2) Budget Uncertainties

The FY 1983 budget discussed here is that proposed by the President in early February. Until recent years, the President's annual budget could be regarded as a firm proposal which would establish the broad outlines of government activity in the coming year, and Congressional action consisted mostly of fine-tuning. A different and confusing pattern has emerged in the budget turmoil of the past two years. President Carter substantially altered his own FY 1981 budget request within weeks after submitting it. President Reagan last March completely overhauled the proposed FY 1982 budget he inherited from President Carter, then revised it again with 12 percent across-the-board cuts in September. This year the Congress has already served notice to the President that his FY 1983 budget is unacceptable, and leaders are proposing a variety of alternatives. What the result will be is anyone's guess at this point, but it seems clear that the final FY 1983 budget will be quite different from the proposed budget described here.

(3) Two-Year Trends

The many major adjustments to the FY 1982 budget during the past year have made the currently-stated figures for FY 1982 budget authority an unreliable benchmark for budgetary trends in many cases. In addition, two major R&D agencies (HHS and Commerce) do not yet have final FY 1982 appropriations; they are funded under a continuing resolution which is due to expire at the end of March. Therefore, in most places in this overview, budget trends and percentage changes are shown for a two-year period (FY 1981 - FY 1983) rather than for a single year (FY 1982 - FY 1983).

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[1] Willis H. Shapley, Albert H. Teich, and Jill P. Weinberg, Research and Development: AAAS Report VII (Washington, D.C.: American Association for the Advancement of Science, in preparation). This report, as well as six earlier volumes in the series, is available from the AAAS Sales Office, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005.

(4) Energy Reorganization

The President has proposed to dismantle the Department of Energy and disperse its functions among a number of other agencies and departments. Virtually all of DOE's R&D activities would go to the Commerce Department, under a new Energy Research and Technology Administration (ERTA). OMB's R&D tables assume this transfer has taken place and show energy R&D in Commerce. Because Congressional approval of this proposed reorganization is far from certain, this analysis shows energy R&D separately, as it is now organized.

Highlights

During last summer and early fall, while Congress and the administration were still deeply embroiled in debate over the FY 1982 budget, OMB and the departments and agencies of the Executive Branch were in the early stages of negotiation on the budget for 1983. The word that filtered down from the bureaucracy during this period was that "if you liked the 1982 budget, you're going to love 1983." Indeed, the FY 1983 budget presented to Congress by President Reagan on 8 February 1982 lives up to this advance billing.

In R&D, as in most other areas, the FY 1983 budget continues and elaborates upon themes laid out in the administration's FY 1982 budget. Defense, which was given a sharp increase in FY 1982, is increased still further in FY 1983; social programs cut in FY 1982 are cut more deeply in FY 1983. On the whole, R&D came out better than most areas of government endeavor, due primarily to a large increase in defense R&D and relatively favorable treatment of basic research throughout the government.

R&D highlights include the following:

- Total budget authority for R&D (including both conduct and facilities) is proposed to rise from $37.3 billion in FY 1981 and $40.0 billion in FY 1982 to $44.4 billion in FY 1983. This represents an increase in current dollars of 11.0 percent between FY 1982 and FY 1983 and 18.9 percent between FY 1981 and FY 1983.
- Taking the effects of inflation into account, the real (constant dollar) increase for total R&D is 3.9 percent over FY 1982, but only 2.2 percent over FY 1981.
- A large increase in defense R&D (up 18.9 percent in current dollars, 11.0 percent in constant dollars over FY 1982) accounts for nearly all of the growth in total R&D; non-defense R&D is nearly level in current dollars (up 0.6 percent over FY 1982) and down somewhat (-6.6 percent) in constant dollars.
- Basic research increases from $5.1 billion in FY 1981 and $5.3 billion in FY 1982 to $5.9 billion in FY 1983. This represents a one-year (FY 1982 - FY 1983) increase of 9.8 percent (2.7 percent in constant dollars) and a two-year increase of 14.9 percent (down 1.3 percent in constant dollars).
- The relatively favorable treatment of basic research is consistent with the administration's stated policy of focusing its direct R&D support on those areas where there is a prospect for significant economic gain for the nation but where the private sector is unlikely to invest adequately.
- Increases in basic research are widespread across the government. Only two major basic research agencies (Interior and Veterans Administration) show current dollar declines (FY 1981 - FY 1983). Many of the increases, however, are less than what would be required to keep pace with anticipated inflation.

- R&D programs of several agencies show substantial current dollar declines over the two-year (FY 1981 - FY 1983) period. These include DOE (which has been proposed for dismantlement, -21.7 percent), EPA (-44.5 percent), Commerce (-30.2 percent, largely in NOAA), Labor (-91.0 percent), and HUD (-47.4 percent).

- The characterization of social and behavioral research as "lower priority," which stood out in last year's budget, is noticeably absent from this year's justification documents. Congress restored a portion of the cuts the administration had requested in NSF's social and behavioral research in FY 1982, and the FY 1983 request holds to approximately the same level (in current dollars) as that resulting from Congressional action.

Outlines of Reagan Administration R&D Policies

The R&D policies of the Reagan Administration have been in a formative stage during the past year while the administration has been concentrating primarily on the overall problems of the economy and the budget. Since his appointment last June, Presidential Science Adviser George A. Keyworth II has been articulating the directions and general approach the administration is taking on R&D policy. The FY 1983 budget, the first actually formulated by the Reagan Administration, represents the first real opportunity to see what these policies mean in terms of concrete program proposals and the rationales supporting them. The result seems to be an orientation to federal support of R&D, which is shaped by broader political and economic currents and which contains some significant departures as well as some continuities with previous policies.

The most explicit statement of the administration views on R&D embodied in the FY 1983 budget is contained in the introduction to "Special Analysis K":

> "R&D activities are supported by the Federal Government in two broad categories, namely, to meet:
>
> - Federal Government needs--where the sole or primary user of the R&D is the Government itself, for example, in national defense and environmental regulation.
> - National needs--where the Federal Government helps to assure the strength of the Nation's economy and the welfare of its citizens through the support of R&D in specific areas such as agriculture, energy, and health.
>
> The 1983 budget reflects a clearer delineation, than has been the case in the past, between the responsibilities of the Federal Government and those of the private sector with respect to R&D to help meet national needs.
>
> The Federal Government has two main responsibilities with respect to R&D to meet national needs.
>
> - First, it should provide a climate for technological innovation which encourages private sector R&D investment that best reflects the realities of the marketplace where new and improved processes and products are developed, bought, and sold. The administration is fulfilling this responsibility primarily by reducing Government spending, regulation and taxes. Thus, the administration's R&D policy is part of its overall economic policy.
> - Second, the Government should focus its direct R&D support on those areas where there is substantial prospect for significant economic gain to the Nation, but where the private sector is unlikely to invest adequately in the national interest

> because the benefits, in large measure, are not immediately "appropriable" by individual firms. Thus, for example, the Federal Government supports basic research across all scientific disciplines but limits its spending on technology development to technologies requiring a long period of initial development, such as fusion power, where the risk is high but the payoff to the Nation is potentially large. This strategy is reflected in the funding for R&D to meet national needs in the 1983 budget."

By way of comparison, the description of the federal role in R&D contained in the Carter Administration's FY 1982 budget was shorter, but more encompassing:

> "Federal R&D ranges from support for basic research to discover new scientific knowledge and applied research to use scientific knowledge in meeting specific needs to the development and demonstration of specific devices, systems or methods. These activities meet needs in three broad categories:
>
> - Direct Federal needs--where the Government is the primary user of the R&D (e.g., national defense).
> - General economic and social needs--where the major responsibility lies with the Government because other sectors do not have sufficient incentive or resources to make adequate investments (e.g., basic research).
> - Specific national needs--where the Government augments private sector investments to accelerate R&D in a particular area of national concern (e.g., energy R&D)."

The differences are significant:

- The Reagan Administration statement specifically subordinates its direct support of R&D to its overall economic policy and highlights the importance of private sector R&D. By implication, reducing the federal budget to facilitate economic recovery is essential, even if it means some cuts in lower priority R&D.

- The Reagan approach limits funding of technology development to long-term, high-risk, high-payoff programs. It makes no mention of the Carter Administration's notion of the government augmenting private sector investment "to accelerate R&D in a particular area of national concern."

The continuities also bear mention, especially:

- An emphasis on R&D to serve the government's own needs, as in national defense.

- Federal responsibility for support of basic research "across all disciplines," particularly significant in view of last year's cuts in social and behavioral research.

- Federal responsibility for R&D to meet certain specific "national needs," including agriculture, energy, and health.

The FY 1983 budget does indeed reflect these themes, as the analysis in this chapter and those in the balance of the report reveal. At the same time, it also leaves a variety of inconsistencies unresolved. Key among these may be the problem of maintaining national strength in basic research, heavily based in academic institutions, while in other, non-R&D parts of the budget, programs upon which universities depend (such as student loans) are being cut back sharply. This and other aspects of the administration's policies relating to support of R&D are certain to receive close scrutiny in coming months.

Major Features of R&D in the FY 1983 Budget

Tables 1 and 2 present summary figures for federal funding of R&D and for conduct of R&D by character of work. The figures in Table 1 allow comparison of patterns of budget authority, obligations, and outlays for FY 1983 and for several past years. All other tables in this chapter (except Table 5) show budget authority only. Table 2 shows the breakdown of aggregate R&D figures into the categories of basic research, applied research, and development. Constant dollar conversions are by the authors using inflation rates derived from OMB's current economic assumptions (FY 1980, 11.4 percent; FY 1981, 12.6 percent; FY 1982, 8.9 percent; FY 1983, 6.8 percent).

Table 1. Total Federal Funding for R&D (in billions).

	FY 1967[1] Actual	FY 1972[1] Actual	FY 1980 Actual	FY 1981 Actual	FY 1982 Est.	FY 1983 Est.
Current dollars:						
Conduct of R&D						
Budget Authority	$16.5	$16.5	$31.6	$35.6	$38.6	$43.1
Obligations	16.5	16.5	31.7	35.0	38.8	43.0
Outlays	16.1	16.2	30.4	34.3	37.4	41.1
R&D Facilities						
Budget Authority	0.6	0.6	1.5	1.7	1.4	1.3
Obligations	0.6	0.6	1.6	1.5	1.5	1.3
Outlays	0.8	0.6	1.5	1.6	1.7	1.2
Total R&D						
Budget Authority	17.1	17.1	33.0	37.3	40.0	44.4
Obligations	17.1	17.1	33.3	36.5	40.1	44.3
Outlays	16.9	16.7	31.8	35.9	39.1	42.3
Constant FY 1972 dollars:						
(Budget Authority only)						
Conduct of R&D	$22.3	$16.5	$16.9	$16.9	$16.9	$17.6
R&D Facilities	0.8	0.6	0.8	0.8	0.6	0.5
Total R&D	$23.1	$17.1	$17.7	$17.8	$17.5	$18.2

Source: "OMB Data for Special Anaylsis K," and National Science Foundation, Federal Funds for Research, Development and Other Scientific Activities, Vol. XXV. Conversion to 1972 dollars by authors based on OMB deflators.

[1] Authors' estimates based on above sources.

Table 2. Conduct of R&D by Character of Work (Budget Authority in billions).

	FY 1967[1] Actual	FY 1972[1] Actual	FY 1980 Actual	FY 1981 Actual	FY 1982 Est.	FY 1983 Est.
Current dollars:						
Basic Research	$ 1.8	$ 2.2	$ 4.7	$ 5.1	$ 5.3	$ 5.9
Applied Research	2.9	3.6	6.9	7.3	7.2	7.4
Total Research	$ 4.7	$ 5.8	$11.6	$12.4	$12.5	$13.3
Development	11.8	10.7	20.0	23.2	26.0	29.9
Total Conduct of R&D	$16.5	$16.5	$31.6	$35.6	$38.6	$43.1
Constant FY 1972 dollars:						
Basic Research	$ 2.6	$ 2.2	$ 2.5	$ 2.4	$ 2.3	$ 2.4
Applied Research	3.7	3.6	3.7	3.5	3.1	3.0
Total Research	$ 6.3	$ 5.8	$ 6.2	$ 5.9	$ 5.4	$ 5.4
Development	15.9	10.7	10.7	11.0	11.4	12.2
Total Conduct of R&D	$22.3	$16.5	$16.9	$16.9	$16.8	$17.6

Source: "OMB Data for Special Analysis K," and National Science Foundation, Federal Funds for Research, Development and Other Scientific Activities, Vols. XXV and XXVII. Conversion to constant FY 1972 dollars by authors based on OMB deflators.

[1] Authors' estimates based on above sources. Basic and applied research figures adjusted to reflect reclassification of DOD research for comparability with current figures.

Several points bear mention:

- Conduct of R&D is up substantially, 11.7 percent in budget authority, from $38.6 to $43.1 billion between FY 1982 and FY 1983. This is more than 4 percent above the projected rate of inflation.
- R&D facilities, cut substantially in FY 1982, are reduced still further in FY 1983, to $1.3 billion. As in FY 1982, much of this reduction is due to termination of several large-scale demonstration plants in the energy area.
- The increase in budget authority for total R&D (conduct plus facilities) between FY 1982 and FY 1983 is 11.0 percent. Outlays (actual spending, as opposed to new spending authority) are projected to rise more slowly, at a rate of 8.2 percent.
- Basic research is projected to increase 2.7 percent beyond the rate of inflation between FY 1982 and FY 1983. Compared to FY 1981, however, basic research in constant dollars shows a small decline, 1.3 percent. (Note: These small changes are obscured by rounding in Table 2.)

Components of R&D Funding: Defense and Non-Defense

The trends shaping federal R&D can be better appreciated by looking at the patterns of funding by functional area. Tables 3 and 4 and Figure 1 present this information. Table 3 breaks down total R&D funding into defense and non-defense components, with a further breakdown of functional areas within the non-defense sector. Figure 1 displays graphically the current dollar data in this table. Table 4 looks inside the figures for basic research, applied research, development, and R&D facilities, disaggregating each into defense and non-defense components.

Table 3. Major Components of Federal Funding for R&D*
(Budget Authority in billions).

	FY 1967 Actual	FY 1972 Actual	FY 1980 Actual	FY 1981 Actual	FY 1982 Est.	FY 1983 Est.
Current dollars:						
Defense[1]	$ 8.8	$ 9.2	$15.4	$19.0	$22.8	$27.1
Non-Defense[2]	$ 8.3	$ 7.9	$17.6	$18.3	$17.2	$17.3
Space[3]	4.7	2.7	4.6	4.9	5.4	6.1
Health[4]	1.3	2.0	4.0	4.3	4.2	4.3
Energy[5]	0.6	0.6	4.2	4.3	3.1	2.2
General Science[6]	0.5	0.7	1.4	1.5	1.5	1.7
All Other	1.2	1.9	3.4	3.3	3.0	3.0
Total R&D	$17.1	$17.1	$33.0	$37.3	$40.0	$44.4
Constant FY 1972 dollars:						
Defense	$11.9	$ 9.2	$ 8.3	$ 9.0	$10.0	$11.1
Non-Defense	$11.2	$ 7.9	$ 9.4	$ 8.7	$ 7.6	$ 7.1
Space	6.3	2.7	2.5	2.3	2.4	2.5
Health	1.8	2.0	2.1	2.0	1.8	1.8
Energy	0.8	0.6	2.3	2.0	1.4	0.9
General Science	0.7	0.7	0.8	0.7	0.7	0.7
All Other	1.6	1.9	1.8	1.6	1.3	1.2
Total R&D	$23.1	$17.1	$17.7	$17.8	$17.5	$18.2

Source: Authors' estimates based on data from OMB and agency budget justifications: "OMB Data for Special Analysis K"; National Science Foundation, Federal Funds for Research, Development and Other Scientific Activities, Vols. XXV and XXVII. Conversion to constant FY 1972 dollars by authors based on OMB deflators.

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[*] Includes conduct of R&D and R&D facilities.

[1] Includes DOD and defense activities in Energy.

[2] Includes all R&D not in Defense.

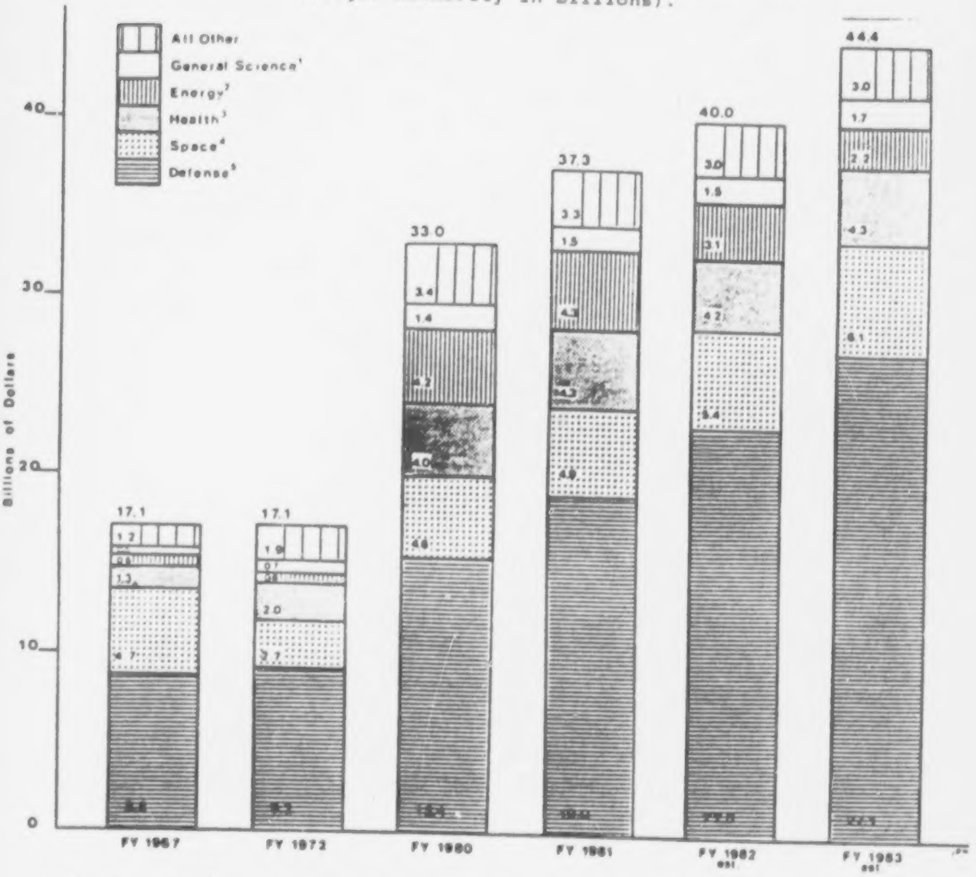
[3] Includes NASA less space applications and aeronautical research.

[4] For FY 1980, 1981, 1982 and 1983, includes health research in HEW/HHS, VA, USDA, Labor, Education, Interior, AID and EPA. FY 1967 and 1972 based on OMB data for health research in all federal agencies.

[5] Includes NRC, EPA energy research, and Energy less defense activities and general science.

[6] Includes NSF and Energy general science.

Figure 1. Major Components of Federal Funding for R&D*
(Budget Authority in billions).



Source: Authors' estimates based on data from OMB and agency budget justifications; "OMB Data for Special Analysis K"; National Science Foundation, Federal Funds for Research, Development and Other Scientific Activities, Vols. XXV and XXVII.

*Includes conduct of R&D and R&D facilities.

[1] Includes NSF and Energy general science.

[2] Includes NRC, EPA energy research, and Energy less defense activities and general science.

[3] For FY 1980, 1981, 1982 and 1983, includes health research in HEW/HHS, VA, USDA, Labor, Education, Interior, AID and EPA. FY 1967 and 1972 based on OMB data for health research in all federal agencies.

[4] Includes NASA less space applications and aeronautical research.

[5] Includes DOD and defense activities in Energy.

Table 4. Defense and Non-Defense R&D by Character of Work (Budget Authority in billions).

	Current $			Constant FY 1972 $		
	FY 1981 Actual	FY 1982 Est.	FY 1983 Est.	FY 1981 Actual	FY 1982 Est.	FY 1983 Est.
Basic Research						
Defense	0.6	0.7	0.8	0.3	0.3	0.3
Non-Defense	4.5	4.7	5.0	2.1	2.0	2.1
Total	$ 5.1	$ 5.3	$ 5.9	$ 2.4	$ 2.3	$ 2.4
Applied Research						
Defense	2.2	2.4	2.7	1.0	1.1	1.1
Non-Defense	5.1	4.8	4.7	2.4	2.1	1.9
Total	$ 7.3	$ 7.2	$ 7.4	$ 3.5	$ 3.1	$ 3.0
Development						
Defense	15.6	18.9	22.9	7.4	8.3	9.4
Non-Defense	7.6	7.1	7.0	3.6	3.1	2.9
Total	$23.2	$26.0	$29.9	$11.1	$11.4	$12.2
Conduct of R&D						
Defense	18.4	22.0	26.4	8.8	9.6	10.8
Non-Defense	17.2	16.6	16.7	8.2	7.2	6.8
Total	$35.6	$38.6	$43.1	$17.0	$16.9	$17.6
R&D Facilities						
Defense	0.6	0.7	0.7	0.3	0.3	0.3
Non-Defense	1.1	0.7	0.5	0.5	0.3	0.2
Total	$ 1.7	$ 1.4	$ 1.3	$ 0.8	$ 0.6	$ 0.5
Total R&D						
Defense	19.0	22.8	27.1	9.1	9.9	11.1
Non-Defense	18.3	17.2	17.3	8.7	7.5	7.1
Total	$37.3	$40.0	$44.4	$17.8	$17.5	$18.2

Source: Authors' estimates based on "OMB Data for Special Analysis K," and agency budget justifications. Conversion to constant FY 1972 dollars by authors based on OMB deflators.

- As Table 3 and Figure 1 show, the growth in total R&D is, in fact, a composite of two distinct trends: (1) a sharp upward trend in defense, and (2) a level-to-slightly-downward trend in non-defense R&D.
- Over the two-year period, FY 1981 - FY 1983, defense R&D (which includes atomic energy defense activities in DOE as well as DOD) is proposed to increase by 42.6 percent in current dollars (22.5 percent in constant dollars) while non-defense R&D declines 5.7 percent (18.9 percent in constant dollars). Within the non-defense sector, a sharp drop in R&D related to energy is partly offset by increases in space and general science.

- In the defense sector, the largest percentage increase is in development, which is slated to grow by 46.7 percent between FY 1981 and FY 1983. Defense basic research also receives a healthy boost of 35.8 percent, while defense applied research receives a more modest increase, 22.5 percent.

- On the non-defense side, the picture is quite different. Non-defense basic research grows between FY 1981 and FY 1983, but only by 12.0 percent, which translates into a small real (constant dollar) decline (-3.8 percent). Non-defense applied research declines 7.1 percent in current dollars (-20.1 percent in constant dollars), while development in the non-defense sphere shrinks 8.7 percent (-21.5 percent in constant dollars).

These figures reflect in rather dramatic fashion the impacts of the Reagan Administration's emerging science and technology policies on federal R&D funding. Defense, an area where the government itself is the primary user of the R&D it sponsors, receives large increases in line with the high priority it has been assigned by the administration. The increase is especially pronounced in development, where near-term payoffs in military hardware are expected to result. In non-defense areas, basic research is favored in view of its potential contribution to national needs and the tendency of the private sector to underinvest. Growth in non-defense basic research is limited, however, by the overall budget austerity imposed on the civilian sector. Applied research and development outside of defense are reduced sharply, in keeping with the administration's more restrictive view of the role of government is such endeavors.

Relation of R&D to Total Budget and Gross National Product (GNP)

Table 5 displays total R&D and basic research in relation to the total federal budget and GNP, for FY 1983 and several prior years. Note that, in contrast to

Table 5. R&D and Basic Research Outlays in Relation to Total Budget Outlays and GNP (in billions).

	FY 1967 Actual	FY 1972 Actual	FY 1980 Actual	FY 1981 Actual	FY 1982 Est.	FY 1983 Est.
Current dollars:						
Total R&D Outlays	$ 16.9	$ 16.7	$ 31.8	$ 35.9	$ 39.1	$ 42.3
Basic Research Outlays	1.6	1.9	4.4	5.0	5.3	5.6
Total Budget Outlays	158.3	232.0	579.6	657.2	725.3	757.6
Total GNP	774	1111	2627	2922	3160	3524
Constant FY 1972 dollars:						
Total R&D Outlays	$ 21.8	$ 16.7	$ 17.0	$ 17.1	$ 17.1	$ 17.3
Basic Research Outlays	2.2	1.9	2.4	2.4	2.3	2.3
Total Budget Outlays	212	232	311	313	317	310
Total R&D Outlays:						
As Percent of Total Outlays	10.65%	7.22%	5.49%	5.46%	5.39%	5.58%
As Percent of GNP	2.17%	1.51%	1.21%	1.23%	1.24%	1.20%
Basic Research Outlays:						
As Percent of Total Outlays	1.02%	0.84%	0.76%	0.76%	0.73%	0.74%
As Percent of GNP	0.21%	0.17%	0.17%	0.17%	0.17%	0.16%

Source: AAAS estimates derived from OMB *FY 1983 Budget* and "OMB Data for Special Analysis K." Conversion to constant FY 1972 dollars by authors based on OMB deflators.

other tables in this chapter, the R&D and basic research figures are in *outlays*, not budget authority, in order to reflect actual spending during the years in question.

As the lower portion of the table shows, R&D as a percent of total budget outlays declines somewhat between FY 1980 and FY 1982, but increases in FY 1983. Compared to FY 1967 and FY 1972, however, the FY 1983 percentage (5.58 percent) still looks low, a reflection of the rapid growth of non-R&D (mainly entitlement) components of the budget in the past decade. The ratios of total federal R&D and federal support of basic research to GNP have remained fairly constant over the past several years, somewhat below their levels of the late 1960s and early 1970s.

Basic Research

The detail by agency for support of basic research is presented in Table 6. The last two columns show percentage changes in current and constant dollars for the two-year period, FY 1981 - FY 1983. As noted earlier, total basic research is projected to increase 14.9 percent over this period. When adjusted for infla-

Table 6. Conduct of Basic Research by Agency in Current Dollars (Budget Authority in millions).

	FY 1972[1] Actual	FY 1980 Actual	FY 1981 Actual	FY 1982 Est.	FY 1983 Est.	% Change FY81-83 Current$	% Change FY81-83 Constant$
HHS[2]	$ 626	$1762	$1954	$1999	$2069	+5.9%	-9.0%
(NIH)	(546)	(1644)	(1768)	(1839)	(1897)	(+7.3%)	(-7.8%)
NSF	368	830	879	910	984	+11.9%	-3.8%
Defense-Military[3]	328	552	610	683	828	+35.7%	+16.6%
Energy[4]	268	523	597	647	741	+24.1%	+6.6%
NASA	332	559	532	580	682	+28.2%	+10.2%
Agriculture	137	280	319	330	359	+12.5%	-3.3%
Interior[5]	--	72	79	73	67	-15.2%	-27.1%
Smithsonian[5]	--	41	45	45	51	+13.3%	-2.6%
Commerce[5]	--	31	16	18	21	+31.3%	+12.8%
VA[5]	--	14	15	13	14	-6.7%	-19.8%
Education	--	18	17	14	14	-17.6%	-29.2%
EPA	--	13	12	11	9	-25.0%	-35.6%
Other	138	21	32	23	29	-9.4%	-22.1%
Total Basic Research							
Current Dollars	$2197	$4716	$5107	$5346	$5868	+14.9%	
Constant FY 1972 Dollars	(2197)	(2528)	(2431)	(2336)	(2400)		-1.3%

Source: "OMB Data for Special Analysis K," and National Science Foundation, Federal Funds for Research, Development and Other Scientific Activities, Vols. XXV and XXVII. Conversion to constant FY 1972 dollars by authors based on OMB deflators.

[1] Authors' estimates based on above sources. NIH estimate is comparable with classification of R&D used in current budgets.

[2] Includes education for FY 1972.

[3] Includes all of DOD budget category "6.1." Source for FY 1972: DOD.

[4] All DOE basic research is proposed for transfer to Commerce in FY 1983; reported under Atomic Energy Commission for FY 1972.

[5] Reported under "other" for FY 1972.

tion, this translates into 1.3 percent real (constant dollar) decline. Among the significant features of Table 6 are:

- The largest real growth in agency support of basic research (16.6 percent) is in DOD; this parallels the general increase in defense R&D. Since FY 1980, the DOD contribution to total federal support of basic research has increased slightly, from 11.7 percent to 14.1 percent.

- Other agencies slated for real growth in basic research over the FY 1981 - FY 1983 period include Energy (6.6 percent, reflecting a substantial boost in high energy physics); NASA (10.2 percent); and Commerce, excluding the units proposed for transfer from DOE (12.8 percent).

- The two-year trend in constant dollars for the largest supporters for basic research, NIH and NSF, is downward. NIH support of basic research will decline 7.8 percent in constant dollars between FY 1981 and FY 1983 under the President's budget, while NSF basic research will slip 3.8 percent during the same period.

- Basic research in Agriculture, which was reduced sharply in the President's September budget reductions for FY 1982, is increased somewhat in the FY 1983 request, but will still lose ground to inflation over the two-year period (down 3.3 percent in constant dollars between FY 1981 and FY 1983).

R&D at Colleges and Universities

Projected levels of support for conduct of R&D at colleges and universities for major federal agencies are shown in Table 7. Agency budgets do not generally include specific allocations for R&D support at colleges and universities; these

Table 7. Estimated Support for Conduct of R&D at Colleges and Universities in Current Dollars (Budget Authority in millions).

	FY 1980	FY 1981	FY 1982 Est.	FY 1983 Est.	% Change FY81-83 Current$	% Change FY81-83 Constant$
HHS	$2077	$2223	$2241	$2293	+3.1%	-11.4%
(NIH)	(1899)	(2001)	(2054)	(2100)	(+4.9%)	(-9.8%)
NSF	661	813	817	885	+8.9%	-6.5%
Defense-Military	455	554	632	736	+32.9%	+14.2%
Agriculture	222	248	265	270	+8.9%	-6.5%
Energy[1]	283	302	271	272	-9.9%	-22.6%
NASA	171	184	191	191	-3.8%	-10.8%
AID	53	78	82	90	+15.4%	-0.9%
EPA	47	53	44	25	-52.8%	-59.5%
Education	65	42	33	36	-14.3%	-26.4%
Interior	44	40	33	24	-40.0%	-48.4%
Transportation	21	18	17	19	+5.6%	-9.3%
Commerce	46	44	34	14	-68.2%	-72.7%
Labor	11	9	3	0	-100.0%	-100.0%
Other	32	20	16	13	-35.0%	-44.1%
Total						
Current Dollars	$4188	$4628	$4679	$4868	+5.2%	
Constant FY 1972 Dollars	(2245)	(2203)	(2045)	(1991)		-9.6%

Source: "OMB Data for Special Analysis K." Conversion to constant FY 1972 dollars by authors based on OMB deflators.

[1] Proposed for transfer to Commerce in FY 1983.

figures are estimates by agency officials, based on budget and program plans, which were assembled by OMB in connection with its special analysis of R&D in the budget. Because of their uncertainties about the reliability of these data, OMB officials chose not to publish them in "Special Analysis K" this year. As the only data available, however, they may serve as a rough guide to federal R&D funding for colleges and universities contemplated in the FY 1983 budget.

In general, trends in federal funding for R&D at colleges and universities tend to parallel trends in federal funding for basic research, since colleges and universities are the primary performers of federally-funded basic research. The 9.6 percent decline (in constant dollars) in total R&D at colleges and universities between FY 1981 and FY 1983 is somewhat larger than the decline in total support of basic research, 1.3 percent. Within the total, however, several different trends are apparent:

- DOD R&D support to colleges and universities shows a significant real increase (FY 1981 - FY 1983), reflecting the announced DOD policy of rebuilding its research presence at universities. DOD's portion of total federal R&D funding to colleges and universities will grow from 11 percent in FY 1980 to 15 percent in FY 1983, according to figures in the table.

- NIH and NSF project real decreases similar to the constant dollar declines in their support of basic research.

- Energy, NASA, and Commerce, all of which show significant real increases in basic research, nevertheless show declines in R&D funding for colleges and universities. In the case of Commerce, this probably reflects the proposed phase-out of NOAA's Sea Grant program. In NASA and Energy, the declines may result from inaccuracies in the data, or they may reflect real differences in planned funding of basic research at universities compared with national laboratories, research centers, and industry.

Agency R&D Totals

The composition by agency of the OMB totals for conduct of R&D and for R&D facilities is shown in the two sections of Table 8. Some agencies with R&D-related activities are not included in this table--the Congressional Office of Technology Assessment and the White House Office of Science and Technology Policy, for example. "Off-budget" agencies such as the U.S. Postal Service and the Synthetic Fuels Corporation are also excluded.

The last two columns of the table show two-year (FY 1981 - FY 1983) percentage changes in both current and constant dollars. In general, the agency figures shown here reflect trends and developments discussed elsewhere in this chapter: nearly 25 percent real growth (FY 1981 - FY 1983) in conduct of R&D in the Defense Department; modest real growth in NASA, reflecting increased space shuttle operations; and real declines in conduct of R&D in most other agencies, in some cases (e.g., Energy, EPA, Commerce, and Labor) substantial. Two exceptions worth noting are AID, with a 2.4 percent real increase over FY 1981, and FEMA (the Federal Emergency Management Agency), whose R&D budget is slated to more than double to $22 million in FY 1983, an increase apparently associated with a build-up in the nation's civil defense capabilities.

Details on the R&D budgets of several key agencies will be found in subsequent chapters of this report. Not discussed here, but considered in detail in several chapters of this report, are the impacts of R&D budget trends on the major scientific and engineering disciplines.

Table 8. R&D in the FY83 Budget by Agency in Current Dollars (Budget Authority in millions).

	FY 1980 Actual	FY 1981 Actual	FY 1982 Est.	FY 1983 Est.	% Change FY81-83 Current $	% Change FY81-83 Constant $
Conduct of R&D:						
Defense-Military	$13,813	$17,060	$20,519	$24,732	+45.0%	+24.6%
NASA	5,084	5,407	5,841	6,513	+20.5%	+3.5%
Energy[1]	4,778	5,000	4,452	3,917	-21.7%	-32.7%
HHS	3,782	3,962	3,952	4,107	+3.7%	-10.9%
(NIH)	(3,188)	(3,334)	(3,427)	(3,533)	(+6.0%)	(-8.9%)
NSF	893	944	958	1,033	+9.4%	-6.0%
Agriculture	697	786	804	838	+6.6%	-8.4%
Interior	404	409	376	350	-14.4%	-26.5%
Transportation	373	393	299	364	-7.4%	-20.4%
EPA	342	375	282	208	-44.5%	-52.3%
Commerce	354	344	291	240	-30.2%	-40.1%
NRC	191	227	223	220	-3.1%	-16.7%
VA	126	143	131	140	-2.1%	-15.9%
AID	119	156	161	186	+19.2%	+2.4%
Labor	249	100	29	9	-91.0%	-92.3%
Education	134	91	74	76	-16.5%	-28.2%
TVA	19	31	33	26	-16.1%	-27.9%
Smithsonian	41	45	45	51	+13.3%	-2.6%
HUD	44	38	19	20	-47.4%	-54.8%
Corps of Engineers	30	30	33	36	+20.0%	+3.1%
Justice	40	30	26	21	-30.0%	-39.9%
FEMA	11	8	9	22	+175.0%	+136.3%
Treasury	12	8	8	10	+25.0%	+7.4%
Other	32	24	22	24	--	-14.1%
Total Conduct of R&D	$31,565	$35,611	$38,587	$43,143	+21.2%	+4.1%
R&D Facilities:						
Energy[1]	$ 991	$ 1,156	$ 859	$ 678	-41.3%	-49.6%
Defense-Military	208	302	358	375	+24.2%	+6.7%
NASA	159	116	99	100	-13.8%	-25.9%
Agriculture	18	31	25	25	-19.4%	-30.7%
HHS	24	50	19	20	-60.0%	-65.6%
(NIH)	(22)	(18)	(15)	(20)	(+11.1%)	(-4.5%)
NSF	19	13	10	16	+23.1%	+5.6%
Transportation	24	15	13	24	+60.0%	+37.5%
TVA	11	1	1	1	0.0%	-14.1%
Commerce	4	2	8	3	+50.0%	+28.9%
VA	10	16	0	3	-81.3%	-83.9%
AID	3	8	8	7	-12.5%	-24.8%
CPSC	3	--	--	--	--	--
Smithsonian	1	1	1	1	--	-14.1%
Interior	6	3	1	0	-100.0%	-100.0%
Total R&D Facilities	$ 1,479	$ 1,714	$ 1,402	$ 1,253	-26.9%	-37.2%
Total R&D	$33,044	$37,325	$39,989	$44,396	+18.9%	+2.2%

Source: "OMB Data for Special Analysis K." Conversion to constant FY 1972 dollars by authors based on OMB deflators.

[1] Bonneville Power Authority R&D functions proposed for transfer to Interior in FY 1983 but no new budget authority requested. All other DOE R&D proposed for transfer to Commerce.

Senator GLENN. Our next witness is Dr. John Deutch, dean of science at MIT and former Under Secretary of Energy and Director of the Office of Energy Research during the Carter administration, will give us his views on the President's science policy, particularly as it pertains to energy.

Dr. Deutch, we appreciate you being here this morning.

TESTIMONY OF JOHN DEUTCH, DEAN OF SCIENCE, MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Mr. DEUTCH. Thank you very much, Mr. Chairman. I wonder whether I should say I am from paradise or simply outside of area code 202.

I am dean of science at MIT and a professor of chemistry. As you mentioned, I served in various positions in the Department of Energy, including as Under Secretary.

I am delighted to have the opportunity this morning to comment on some of the matters that are being so ably considered at this session. I am especially concerned with the subjects of energy, national defense, and basic research.

I would like to stress, Mr. Chairman, that I am speaking to you today as an individual. I am not speaking for MIT or for any other organization.

With your permission, sir, I would like to submit my prepared comments for the record and briefly summarize them for you.

Senator GLENN. The record will include your comments in full.

Mr. DEUTCH. I am very well aware of the initiative you have taken, Mr. Chairman, and other members of this committee in examining the state of health of research and development in this Nation. Let me quickly add that I believe Federal research and development expenditures are an absolutely essential investment both in trained individuals and in knowledge to build up our capability for innovation in our economy and our ability to compete in international markets.

I think it is paramount that we recognize the very long-term productivity that these kind of investments make. And that the Federal Government has a key role. Any person who tries to argue that one can do research and development activities in this country if it bears on commercial enterprises without Federal assistance is, in my judgment, very sadly misguided.

There are good reasons for Federal involvement. As most individuals who are familiar with industrial research will tell you, particularly in times of economic difficulty and in times of high interest rates, the private sector is unlikely to be able to or to be willing to undertake the basic work or even applied research required for the long-term health of the economy and for their industrial sectors. In particular, research has outcomes that are quite uncertain, both in terms of when they will occur and who they will benefit, so it is very difficult for those firms to capture the benefits of the research.

Typical examples which are given are the development of instrumentation which is a key to progress in a modern industrial society and basic data of all types undertaken by one firm but shared by all. These kinds of activities are evidence of why every modern society recognizes the Federal obligation to support basic and applied research.

It is also understandable that in times of tight budgets, enormous budget deficits, economic recessions, and other unhappiness in the economy of this Nation that R. & D. programs receive special scrutiny in the budgetary process; that is to be expected. Unfortunately, during that process all too rarely one focuses on today's budgetary costs rather than the productivity which arises from the long-term benefits of the investment.

In that regard, I think it is important that there is external advice in the research and development program planning and budgeting process at all levels.

I am delighted that the White House has established a White House Council. I think it is long overdue. The individuals on it and its chairman are outstanding and I welcome that as I welcome the Energy Research Advisory Board which Mr. Carey mentioned he was a member of.

In order to be brief, I would like to discuss two subjects. The first has to do with the administration's proposal to abolish the Department of Energy and how that impinges on the research and development strength of energy technology. And the second are some very specific recommendations about the Department of Energy R. & D. budget for 1983.

It may be remarked that proposed DOE reorganization is not the first on the agenda of the Congress of the United States despite the fact that it has been proposed in the budget before you. But, let me once again remind you, if you are out there working in a university or in a national laboratory such as Argonne or Brookhaven, or Berkeley or Livermore, or Los Alamos or Oak Ridge, the fact that that proposal is in front of Congress is indeed important in terms of morale, the planning for the future and a whole series of institutional questions which influence their productivity. It is just as important as the level of budgets.

So, even though it may be considered rather dormant this week in Congress, it is in my judgment a very serious subject nonetheless for the productivity of the individuals who are in our energy technology community.

Senator **Glenn**. May I interrupt you there.

It is of great interest to me because this room will be the scene of those Department of Energy reorganization hearings one of these days.

I have thought for many years, for a couple of decades, what they really need is a department of science and technology as most other nations have around the world. I know this gets into some controversy in the scientific community itself. But, what if we took DOE—and I am playing with ideas here, I am not ready to propose this yet—what if we took DOE and made a department of science and technology and left the DOE function under it and added some of these other things that are spread all over the lot now and really made this a department of science and technology.

Would you favor that or would you be against that?

Mr. **Deutch**. I would not want to react to a proposal to make the Department of Energy into the department of science and technology. I wouldn't mind if you put the Department of Commerce under the Department of Energy.

Let me say I am very familiar with the German ministry that was mentioned earlier by Senator Percy, that our system which has a National Science Foundation, the Presidential Science Advisor and a variety of Government agencies which have major science missions, is really quite a successful one and I would not think that much could be gained—in fact, something might be lost—by going to a cabinet level science and technology ministry.

On the other hand, I share with you the motivation that leads you to look to these kinds of steps.

Let me quickly mention that in my judgment the proposal to do away with the Department of Energy reflects a complete misunderstanding of our Nation's economy problem. It doesn't reflect the understanding of the appropriate role for Government in the energy area, and it doesn't represent an understanding of what energy research development is about.

There is no way that the proposed reorganization could help energy research and development, which is the principal item which is of concern to me. And, indeed, if you look at some of the language in the administration's reorganization proposal, one finds what I think is perhaps the greatest oversight of the lesson of recent history that we have in front of us. It says, "Energy is primarily a factor of production subject to the same play for forces as other economic factors." And it also says, "There is no more justification for a separate Department of Energy then for steel, computers, or water." And that breathtaking remark I think ignores the essential reality how energy is distributed over the globe, particularly the Middle East, the unbelievable importance oil has for this Nation and other nations of the globe, and the importance of making progressively more costly and scarce fossil fuel resources into alternative energy sources.

I would like to proceed more rapidly. I don't want to dwell on why I think the Department of Commerce does not have the record for being able to manage energy research and development.

The Department of Commerce has two important technical agencies, one is NOAA, which has been quite successful, primarily because they are almost completely separate from the Department of Commerce, and the second is the National Bureau of Standards. I was fortunate enough to spend a year there myself in 1964, and we have heard from Mr. Carey about how their functioning is being restricted under the present administration.

The only part of the proposal for the Department of Energy which makes sense is not to separate weapons and energy functions. I think that is very important for this committee to understand why this is so, even though it may lead to the ludicrous result that one has weapons in the Department of Commerce.

I think it is important that the technical basis of the connection between the connection of energy R. & D. and the weapons program is understood. They are extremely important, and as a result of historical accident are mutually supportive. I think by separating them now in any way would be a very serious mistake.

As you know, and we have mentioned, there are several national laboratories that do outstanding work both in defense and energy, Sandia Lab in New Mexico, Livermore and Los Alamos as well. There is a field structure to undertake major projects. The infrastructure can be used both for energy projects and for defense projects.

For all of these reasons, the common heritage, the field structure, and the laboratory structure, I think it is important that whatever happens that these two functions remain together.

I prefer to see a cabinet-level department remain in energy. I believe energy is going to be one of the two or three of the most difficult problems for us and our allies in the coming decades and deserves cabinet-level attention. If one doesn't do that, I would suggest an independent agency such as NASA. Under no circumstances do I think it will make sense, will it help the energy R. & D. functions or national defense function to put energy under the Department of Commerce or, God forbid, Interior.

Next, Mr. Chairman, I would like to spend a few moments on the energy R. & D. development for fiscal 1983.

In my testimony, which I will not try to repeat in detail here, I go through all of the major energy functions. And I point out in each area where I think substantial additional resources are required. I do think, Mr. Chairman, without apology, and in full recognition of the major difficulties that this Nation faces, the size of its deficit, I would like to provide you a technical judgment of a person who was a manager of the programs in the agency, the technical judgment of what would be done to put those programs on a sound footing.

Now, I fully admit that the fiscal 1981 budget, the last one for which I was responsible, in the Department of Energy, that there were places where there was too much expenditure, partially as a result of administration proposal, partially as a result of congressional action. Not all expenditures are justified and we all recognize that. Nevertheless, I think it is important to realize what we have in the fiscal 1983 budget is disassembly of some of the more important energy R. & D. functions in this country.

Let me briefly pursue some of these. First, as you know, sir, the Department of Energy carries on as a national trust activity, again because of historical precedence very important basic science activities—high energy and nuclear physics and extraordinary life sciences and nuclear medicine activities. In general, I think that these have been some of the most successful scientific enterprises carried out by mankind, and in my view the budget for these activities is not yet adequate.

I have some specific recommendations or priorities which should be pursued particularly in the high energy physics area.

The basic energy sciences area in conformity with what was said today by my friend, Doug Pewitt, did receive a substantial increase in the Department of Energy's fiscal 1983 submission. I believe that is the highest priority in the entire program and I think it should be the highest priority to maintain the requested level of $283 million relative to $243 million in fiscal 1982.

Senator GLENN. Were these cut last year?

Mr. DEUTCH. I believe they were not cut from fiscal 1981 and fiscal 1982. That specific program is an extremely important program because it contributes essential underpinnings of material sciences, chemistry, nuclear science, engineering, applied mathematics, geosciences, and biological energy conversion. There is no question the types of activities undertaken here are not being undertaken in the private sector whatsoever.

Senator GLENN. This is one that really would be having an increase that keeps up with inflation.

Mr. DEUTCH. It has ups and downs but, generally speaking, this program has received adequate attention. That is the only time I will say that.

The magnetic fusion program has been cut by $10 million. The magnetic fusion program is not about to solve our energy problems tomorrow. There is a variety of different trends within the magnetic fusion program but I would like to indicate to you, sir, that there has been sustained and excellent technical progress in the magnetic fusion area. There has been legislation passed in Congress last year I believe by the Senator from my State, that indicates where, roughly speaking, magnetic energy development should go.

The proposed fiscal 1983 administration proposal would set magnetic fusion energy back substantially from what was envisioned 1½ years ago. I believe that is most unfortunate.

Let me next turn to fossil energy. Ever since 1973 members of every administration, experts from every walk, have come here and indicated the importance to the United States of utilizing coal. Coal is an absolutely critical item to learn how to use in an environmentally effective manner and in a low cost manner in the near term for burning in utilities to produce power or burning in industry to produce processed steam, and so forth.

In the long run coal will be a source of synthetic fuel and gas.

The fiscal 1983 budget for coal is $95 million. In fiscal 1981 the coal and other fossil fuel programs—that is, coal, enhanced oil recovery, and shale—amounted to $1 billion. That means we have a policy here to take the Federal Government out of coal, out of mining, out of liquefaction, out of surface gasification, underground gasification, environmental control technology which would permit us to burn 2.5 to 3 percent sulfur coal, more efficient heat engines, combustion engines, fuel cells, and MHD.

In all of these areas we have essential elimination of the Federal Government's programs.

In my judgment this is remarkably shortsighted. It is distinct from the action of every other modern technical society in the East and West, and in my view it would be well advised for this Nation to add $700 million to these programs in a variety of areas that are indicated in my testimony.

Senator GLENN. Have you been able to note any move of the private sector to take up any of that slack at all?

Mr. DEUTCH. The private sector is moving in the opposite direction. I don't think that it is that they don't realize the importance of this but rather they are facing very severe recession, they are facing substantially high interest rates, they are facing competition from abroad.

I would say to you that in the circles in which I travel, and quite conservative circles, I might add, of the private sector, they understand what is being lost here on the research and development in these areas.

I might also say to you, sir, that the coal industry is not noted for its high technology and its research and development sophistication. It is a particular need to build over time what has been done in the space, health, other areas in infrastructure which allows technology innovation to occur more rapidly.

Senator GLENN. I couldn't agree with you more, and we have some innovation and some research by outfits like Battelle in Columbus doing work in high sulfur coal and areas like that. We have an abundance of that kind of coal, and if we just did the research we could increase our use of it. Acid rain problems, which comes in part from that, we are not sure where all of it comes from yet, but at least that is part of it.

Those companies don't have the wherewithall or the organizations to do it themselves. They don't have the money.

Mr. DEUTCH. Those moneys have been cut back substantially. The advanced research technology, to my understanding, has been cut back from $56 million in 1982 to a requested $20 million in 1983. I would recommend that that program be returned to a level of approximately $50 million.

The record in renewable energy and conservation technology is equally appalling. I would note that President Reagan in the 1983 budget submission requests $101 million down from $518 million appropriated in fiscal 1982 and I believe, as you pointed out, roughly $750 million in the fiscal 1981 budget.

Let me tell you that our record on conservation technology as a nation is very poor indeed. We have not put into place technically, either in the Department of Energy programs or the private sector, a sufficient emphasis on developing new technology that will utilize energy more efficiently and more effectively. That goes all the way from near-term questions of industrial energy conservation technology to very long-term questions such as super conductive wire cables, combustion science, catalyst.

In my judgment, substantial increments should be made to the budget for conservation technology, the area of the building and community system, transportation, and industry.

I am delighted to note that there is a new category in the budget, multisector, which is going to provide some money, some increased money for basic conservation technology work such as lubrication.

Renewable energy has disseminated in this fiscal 1983 budget. It was disseminated first in fiscal 1982 and again in fiscal 1983. While again I don't want to represent to you or anyone that renewable energy will provide the bulk of our energy resources in the near term, let me say to you that it is inevitable the the globe is going to run out of oil and gas, it is inevitable that we will run into a major CO_2 problem by massive utilization of coal. In 50 years, maybe 70 years down the pike, this world will have to use other energy resources including in a very major way solar heating, solar passive, photovoltaic, solar thermal, biomass, and wind. These new types of energy resources will require aggressive and substantial research and development. The Carter administration might have ramped up too rapidly, but this present administration budget is ramping down too rapidly .

You mentioned electrical energy storage system. Here again I want to emphasize to you batteries are, and I agree with you, Mr. Chairman, a very central part of utilization of renewable energy sources and even an important part of making efficient utilities. Let me say to you the proposed request for energy storage is zero compared to $38 million in fiscal 1982 and in the mid-1950's in fiscal 1981. This is not a sensible way to proceed in executing, planning, or appropriating money for energy technology in this country.

In summary, I think a substantial addition of roughly $250 million is required for renewable energy technology to be put back on a sound track. It would still leave it substantially below the fiscal 1981 level that was requested in the Carter administration.

I conclude my brief remarks with nuclear energy because here is the only place in the budget where there is clear evidence that the Reagan administration will not rely on the private sector in its action. It is proceeding with, I believe, $250 million requested for the Clinch River Breeder Reactor.

As you are aware, the reduction in the demand for electricity coupled with a series of other difficulties of nuclear power has led to a substantial slowdown in the demand for nuclear power. It is more cost-effective to use light water fission reactors. Anything else is unsustainable on the basis of analysis.

I happen to be very much for nuclear energy myself. I believe it is extremely important for the United States. It is much more important for our allies who don't have the luxury that we have of having major coal reserves and other types of resources. But, it is not the time, nor is it needed, to go toward breeder commercialization. In fact, there is no need to begin an outdated, obsolete Clinch River Breeder Reactor project that was designed in 1968 and at a time when we expected the rate of growth of nuclear to be quite different.

I favor breeder research and development, but I do not believe that we require investment in a CRBR project at this time.

I could pursue my views on what is required in nuclear energy, working on light water reactors, making them safer, more reliable, more efficient, working on radioactive waste programs, not attempting to leave that to the private sector, a most unlikely event indeed.

Here there is no need to add money to the nuclear budget proposed by the administration in fiscal 1983 but substantial reapportionment, in my judgment, is called for.

Permit me to conclude by making three points. First, I don't believe the private sector, nor do I believe any knowledgeable person should really believe, can be expected to undertake all needed energy research and development. A policy which is based on that assumption places our energy future seriously at risk.

Second, I believe that the proposed Department of Energy reorganization is severely misguided, it will not save money, it will not improve our energy research and development performance.

Finally, I have given you some recommendations about adjustments which I believe are needed for the energy research development budget of the DOE and I hope that they will be of assistance to you.

Thank you very much, Mr. Chairman.

Senator GLENN. Thank you very much. An excellent statement.

Let me come back to the energy storage system. This has been a pet of mine for a long time because I see it as being the key to so many other things, and we have had conversations about this before when you were with the previous administration. To see these things being zeroed out, I can't express how ridiculous I think this is because those are not items that are going to be automatically taken up and pursued by private industry or business. They are experimental and they need some basic breakthroughs.

For example, the Redox system, which I remember is something that the Lewis Lab in Cleveland was working on for storing large, massive amounts of electrical energy has future promise and it is to the point now where they needed a half a million to go the next step and it is being zeroed out, and the program is being terminated. That to me is tragic, for lack of a half million with out $700 plus billion budget and for something that promises to let you store the windpower and wave power. And if the breadboard models hold up, you would get back 70 percent of the electrical energy you put in—that is their figure. And we can use all these forces of nature, convert it to electricity, get it back out, we can use it for load leveling, we can use it for input of powerplants, perhaps, and get that power back out again at nonpeak load periods, so you don't have to build new powerplants. And for lack of one-half million dollars this administration is zeroing that out. I think this is preposterous.

You can take specific projects on down the line. Others in the battery storage area, new types of batteries, like this aluminum-air concept at Livermore, that needs more development. It is a very basic thing. It is so basic you are not going to have any company jump into that and put a lot of money into it, but it has such potential that it is well worth the Government getting into it.

If the Department of Transportation figures are correct, they tell us that 92 percent of the noncommercial driving in this country is done within 20 miles of our homes. Right now with the cold weather we can build electric cars reliable for maybe 50 miles and I don't want to be stranded half way out George Washington Parkway going home at night.

So, we need this. If we had any breakthroughs in that area we will be set to save hundreds of millions of barrels of imported crude. It seems to me if we can make a breakthrough in concentrated electrical storage for auto use and then massive electrical storage so we can store the forces of nature, that we know how to convert to electricity, those are tremendous advances, and they are being zeroed out.

That is not a question; it is a statement, obviously.

The Electric Power Research Institute and DOE are joint partners in operating a battery test facility in New Jersey called the Battery Energy Storage Technology Test Center. I think you established that.

Mr. DEUTCH. I think it was started before my time. It is a 4.8-megawatt facility out there in New Jersey.

Senator GLENN. In fiscal year 1983 both DOE and EPRI were originally supposed to contribute $6.5 million toward the operating costs of this facility. As a result of the budget cuts, there will be no DOE contribution and EPRI will now be forced to shoulder the entire cost of running the facility. According to EPRI officials, the likely result will be that EPRI will have to divert money originally planned for research in advanced battery technologies to the operating fund for the test center. In other words, the Reagan budget cuts in this area are producing a situation in which, at least in this instance, private industry is going to be putting less money into advanced research rather than more.

Mr. DEUTCH. That is a very good point to be made, particularly in this area where you have a GRI research institute and EPRI, the way private sector will take up this money is by financing the biggest demonstration projects and compromising their long-term exploratory development work.

Senator GLENN. The sunset review mentioned has this to say about the industrial conservation program which has been zeroed out—that is another one. It says the program has saved an estimated $6.5

trillion Btu's per year and that "The Industrial Conservation Program has had a direct impact on the industrial sector by creating new jobs for equipment manufacture, operation, and maintenance. It also has produced the cost of U.S. goods and has made possible an increase in Federal tax revenues from increased corporate profitability." Since the Reagan administration's review of the industrial conservation program shows it to be such a valuable program, can you imagine why they are zeroing out that system?

I just think these cuts are pennywise and in this year's budget perhaps they are pound ridiculous for the future, as I said earlier.

Time is getting away from us. We appreciate your being here.

[The prepared statement of Mr. Deutch follows:]

United States Senate
Committee on Government Operations
Subcommittee on Energy and Nuclear Non-Proliferation

Statement of John Deutch

March 9, 1983

Mr. Chairman, and Members of this Sub-Committee, my name is John Deutch. I am Dean of Science and Professor of Chemistry at the Massachusetts Institute of Technology. From October 1977 until April 1980 I served in various positions in the Department of Energy including as its first Director of Energy Research, later as Acting Assistant of Energy Technology, and finally as Undersecretary of the Department.

In these positions and in my other activities I have formed opinions about the science and technology needs of this nation, especially in the areas of energy, national defense, and basic research. Accordingly, I am pleased to be invited by this Sub-Committee to present some of my views on how well we are meeting these needs. I wish to stress that I am speaking to you as an individual and not for MIT or any other organization.

Introduction

I am well aware of the initiative that members of this Committee have made in examining the state of health of our R and D enterprise. I applaud these efforts. It is essential that we all recognize how vital today's R and D effort is to the future economic vitality of this nation and to its military strength. Federal R and D expenditures, especially for basic research, will provide the technically trained individuals and the new ideas and knowledge that determine the innovative capacity of our country. Our ability to sustain innovation is vital to our ability to maintain economic growth and to compete in international markets.

It should be apparent that the federal government has a major role in this R and D activity. The private sector simply cannot be expected to undertake the required amount and type of research for several reasons. Perhaps the most important reason is that the benefits which flow from fundamental research efforts are unpredictable, long term, and transferable between fields. It is difficult for private firms to capture a portion of these benefits to defray the cost incurred in performing such research. Accordingly one should expect that private sector investment will be substantially below what might be considered as optimal for the economy. There are many examples where this is true: basic technical data, instrumentation, materials science, very large experimental facilities, pioneer projects that demonstrate the technical feasibility, cost, and environmental effects of a new technology.

But the uncertainty in long-term pay-off which justifies federal R and D programs, for example in space science, also makes precise calculation of the appropriate level and distribution of R and D effort, difficult. Thus, it is not surprising at a time when we are all disappointed at the government's inability to control the size of the federal deficit, that R and D programs receive special scrutiny. Unfortunately, frequently this scrutiny focuses on current budget cost and does not take adaquately into account the powerful, but uncertain, future investment value of the intellectual capital that is created today.

An especially important mechanism to counterbalance this understandable tendency for federal budgetary process to lose sight of technical opportunity and technical quality is the participation of qualified scientists and engineers in providing advice to federal R and D managers. This participation should occur at many different levels including at the White House in the Office of Science and Technology Policy. For a variety of reasons it has proven progressively more difficult to marshall such technical advice in recent years. Therefore, I particularly welcome the recent Administration action in establishing such an outside advisory group, the White House Science Council, under the leadership of two outstanding individuals, Sol Buchsbaum of Bell Laboratories and Ed Frieman of Science Applications Inc. I expect major contributions from this group to improve federal Science and Technology policy and programs.

The Administration's FY83 budget certainly suggests that such outside technical advice might be useful. No where is this more apparent than in the Energy R and D program included in the FY83 budget. It is interesting to contrast the submitted program with the R and D recommendaitons made by DOE's own Energy Research Advisory Board (ERAB) Research and Development, chaired by another outstanding individual, Johnny Foster of TRW. While I do not agree with all of the ERAB recommendations, the views expressed in the ERAB report are much closer to my own than the Administration view about energy R and D implied from the FY83 budget.

Today, I should like to address two subjects. The first subject is the Administration's proposal to abolish the Department of Energy and transfer the bulk of its functions to a newly created entity in the Department of Commerce called the Energy Research and Technology Agency (ERTA). The second subject concerns the FY83 energy R and D budget presently under consideration by Congress.

The Proposed DOE Reorganization

It is my judgment that the Administration's proposal reflects a total misunderstanding of the nature of the energy problem facing this nation and its closest allies, the appropriate role for government in the energy area, and the requirements for effective and efficient government operation.

Should the Administration proposal be adopted, there is a significant risk that both our short-term and long-term energy future will be endangered. The reorganization proposal certainly does not have the potential to improve energy R and D, including basic research because, it reduces attention on this important area and because it places energy technology into the Department of Commerce which is ill-equipped to manage R and D programs.

There are two alternative courses of action that are much preferable to the Administration's proposal. The preferred option, in my view, is to maintain energy as an executive level department and to enhance the capability of DOE to deal with energy problems. The next best option would be to re-establish DOE as an independent agency, similar to NASA or ERDA, the agency which preceeded DOE. It does not appear reasonable, given the conditions which we will be facing, to place the major portion of DOE's functions in an agency such as Commerce or Interior that has not the expertise of competence to carry out the major energy functions.

The Administration fact sheet which is intended to provide a rationale for the proposed reorganization is completely inadequate in framing the issues surrounding the appropriate mission and organization for federal intervention in energy matters. No objective analysis has been presented of the pros and cons of alternative organizational relationships. More importantly, the fact sheet contains statements which indicate that Administration policy-makers have yet to understand the nature of energy problems. For example, the fact sheet states that a primary reason for abolishing the Department of Energy is that "energy is primarily a factor of production subject to the same play for forces as other economic factors" and "there is no more justification for a separate Department of Energy than for steel, computers, or water." This breathtaking remark ignores the essential reality that distinguishes energy from other factors of production, such as 1) energy is essential for industrial production; 2) it is a depletable resource; and most significantly, 3) it is not distributed equally over the globe. Most oil is found in the Middle East and other areas of the world that are politically unstable and/or unfriendly to the U.S. and its allies. It appears that the Administration policy-makers who put together the reorganization proposal are unaware of 1) the essential linkage between energy and security; 2) the economic consequences, throughout the free world, of adjustment to price shocks; and 3) the need for the U.S. and its allies to develop alternative energy sources to replace progressively less secure and more costly oil and gas.

The fact sheet also suggests that the Department of Commerce "has substantial experience in managing R and D activities" and that Commerce's "close working relationship with business" will encourage energy technology applications. In my judgment, this view is wrong. The Department of Commerce has a poor record of managing or understanding R and D and it has no technical expertise for this task. NOAA is the single exception to this generally poor record and one should note that the NOAA has little direct relevance to business; its success is largely due to the weakness of its connection to Commerce.

Finally, the fact sheet implies that the reorganization will result in reduced administrative costs. No evidence is presented to support this claim and indeed it is unlikely to be true. Both the substantial organizational transition costs and the presence of an extra management layer between energy program managers, the OMB, and the responsible Congressional Committees suggest that cost would increase rather than decline.

In sum, the Administration rationale for the proposed reorganization is flowed both in terms of its fundamental assumptions and its specific claims. The implication that the existence of an energy department leads to overregulation, overspending, and isolated energy policy formulation ignores checks and balances present in the federal system and especially the role of Congress. One cannot escape the impression that the Administration actually believes that our energy problems will go away if we pretend they do not exist.

The most important observation I wish to make, Mr. Chairman, concerns the prospect for energy R and D under the proposed reorganization. The requirement for energy R and D is quite broad. It spans basic energy sciences, environmental R and D, R and D for improved energy efficiency, and new energy sources. The range of new energy sources of interest include synthetic fuels, coal combustion and utilization, advanced nuclear systems and breeder reactors, fusion, and renewable energy technologies such as solar, geothermal, and wind. I cannot stress sufficiently strongly how important I believe these energy R and D activities to be to the long-term energy future of the nation. Further, I confess that I have viewed with concern the decimation of these programs that has occurred in the past year during the budget process. I do not wish to imply that the Carter Administration energy R and D program was perfect of that the funds requested and/or voted by Congress for energy R and D were always justified. But I do believe that the basic thrust was correct.

The type of energy R and D required is extremely diverse. A proper appreciation of its character will help to indicate why it is not necessary or sufficient to have the type of connection to the business community that it is alleged the Department of Commerce possesses. It is more important to build and maintain an organization that possesses technical competence to accomplish demanding R and D tasks that, if successful, will be adopted by the private sector.

The type of R and D that is needed includes:

1) Basic energy sciences and engineering research in materials, catalysts, geology, etc., that serve to support many uses in several technology areas from geothermal to nuclear waste disposal. This function includes the collection of basic data and the development of generic instrumentation that assists not only in the optimization of energy production, but also efficiency of utilization.

2) Engineering development of components, advanced concepts, and a few demonstration projects (particularly in the area of solar energy and coal) that provide public information to prospective investors on the practical operating characteristics, costs, and environmental effects of alternative technologies.

These R and D tasks are more demanding than the traditional govenmental R and D functions of defense, space and health. The reason is that energy R and D requires attention to the delicate task of transition to the private marketplace. It is understandable, but nevertheless incorrect, to believe that the Department of Commerce has some special competence to deal with this important subject of the transition from government supported R and D to the marketplace. But remember, the Department of Commerce has been around a lot longer than has this Administration and likely will survive it. The past history of the department does not indicate any evidence of experience or success with technology development or technology transfer to the private sector. Thus, the central question we should ask "Does it seem reasonable that the institutional structure of the Department of Commerce will be a sound base for public action on energy R and D?" The answer is no.

My second observation is that the only correct aspect of the Administration proposal is that defense and energy programs have not been separated. There are three reasons why such separation would be most unwise.

First, several of the atomic Energy Defense activities bear a close relation to civilian energy technologies; examples include naval reactors, inertial confinement fusion, high level radio-active waste management, and isotope enrichment. Second, as a result of common heritage, there is a strong energy technology competence in the DOE weapons labs; Livermore, Los Alamos, and Sandia. It is likely that if the energy technology and defense functions were split up, both functions would suffer considerably. Third, there is an extensive field structure of DOE that is dedicated to implementation of both energy and defense programs. If the energy and defense functions are split-up, the considerable field capability will be lost to one function or the other. Thus it is my strong recommendation to this Subcommittee that the energy technology and defense function must be kept together -- even if this leads to the absurd result that the R and D production, and testing of nuclear weapons falls under the responsibility of the Department of Commerce.

The weapons and naval reactors programs are examples of well-managed technical national security programs. They have functioned well for over thirty years from the base of an independent agency. To suggest that these programs can be better managed by the Department of Commerce is ludicrous. To put it bluntly, for the DOE Defense Programs, this change amounts to fixing something which is not broken. The best that should be expected is that the Defense Programs will not suffer from the transfer; there is no reason to expect that they will benefit. And the best procedure to assure that our critical defense needs are not har- is to establish a structure for ERTA that provides for essential independence from Commerce management control.

Specific Recommendations for the FY83 Energy R and D Budget

No where is the weakness in the Administration's Science and Technology policy more evident than in their FY83 budget submission for energy R and D. I would like to comment on some of the most evident shortfalls and to indicate the adjustment that I would view as reasonable for restoring an aggressive and comprehensive energy R and D program that would adequately equip this nation to face our energy future.

1) General Science The DOE program contains several activities that have traditionally been sponsored by DOE and its predecessor agencies as a national trust activity. These programs which include High Energy Physics, Nuclear Physics and General Life Sciences/Nuclear Medicine, not only contribute to our fundamental knowledge, they also contribute essential underpinings required for advances in a wide range of energy supply and utilization technology. These General Science programs are the "fundamental research programs" of the DOE.

The following table summarizes my recommendations compared to the FY83 Administration request.

Millions $ BA	FY82	FY83 Administration	Recommended Addition
High Energy Physics	365	429	+40
Nuclear Physics	134	131	+15
Life Sciences/Nuclear Medicine	47	39	+14

The High Energy Physics addition would permit (approximately) a return to the DOE/OMB 1978 agreement that was designed to bring stability in planning for and utilization of large accelerator facilities. The present funding level does not permit pursuit of the programs required to main world leadership identified by the recent "Long Range Planning Study" of the DOE High Energy Physics Advisory Panel. In my judgement the priority needs are a) physics experiments at existing accelerators, b) aggressive completion of the TEV-I and TEV-II projects at FERMILAB, c) pursuit of the Single Pass Collider at SLAC and, should the recommended addition be made, (with an accompanying commitment to out year costs) construction of the ISABELLE Accelerator at Brookhaven.

There is no justification in my judgement for the absence of a cost of living increase for the Nuclear Physics Program. The recommended addition would assure a constant real level of effort for a program which over the years has produced vast intellectual advances that have led to impressive practical technical applications.

No program, however, has made greater contributions than the General Life Science/Nuclear Medicine program. For several years this program has not received support adequate to compensate for the effects of inflation or commensurate with the long-term achievements of nuclear medicine or life sciences. Accordingly, Congress should restore a level of funding for this program that would provide approximately the samel level of resources, in real terms, as were made available in FY82.

Basic Energy Sciences and Magnetic Fusion

The more important program in DOE is the Basic Energy Sciences (BES) program. This program contains the basic research support for both universities and national laboratories to undertake work in disciplines that bear directly on energy technologies. Examples of these disciplines include material sciences, chemistry, nuclear science, engineering, applied mathematics, geosciences, and biological energy conversion. Past history indicates that this program has made enormous contributions in diverse areas that have led to major development efforts, e.g. magnetic and inertial confinement fusion, advanced isotope separation and techniques to study catalysis and combustion.

I am pleased to see that the FY83 Administration request of $283M (BA) represents a substantial increase over FY82. In my judgement maintaining the requested FY83 level for BES is the highest priority in the DOE submission.

Magnetic fusion holds the promise for essentially inexhaustible energy production. The Administration FY83 proposal appears to reverse the steady progress that the program had been enjoying in the recent past as a result of impressive technical accomplishments. The FY83 budget request is $10M below FY82. Operating expenses will receive a substantial increase, made possible by a reduced requirement for construction funds due to the completion of TFTR at Princeton. However, insufficient resources are provided to pursue the next generation of experimental machines, e.g. the mirror machine, MFTF-B at Livermore, or to pursue new facilities that begin to explore the engineering development questions of magnetic fusion. Approximately $30M is needed for these purposes in FY83 beyond the amounts requested.

Millions $ BA	FY82	FY83 Administration	Recommended Addition
Basic Energy Sciences	243	283	0
Magnetic Fusion	454	444	30

Fossil Energy

In two years the Reagan Administration has reduced the Fossil Energy R and D program from a FY81 level of close to $1b to a Fy83 budget request of $107M. This reduction flows from Administration philosophy that decontrol of oil (but not gas) and reliance on the free market is essentially adequate to achieve desirable fossil R and D. The federal role is to be limited to generic technology base activities.

The emphasis on the technology base and high risk/high pay-off R and D is welcome. However, the resources provided are neither sufficient for this purpose or for the exploratory development of a wide range of advanced fossil technologies that could play an important role in the relatively near term, e.g. coal/oil mixtures, advanced coal combustion, and environmental control technologies and in the long-term e.g. liquid and gaseous synthetic fuels technology.

The Administration is sadly mistaken in its belief that the private sector can and will bear the costs, in these times of high interest rates and economic recession, to develop needed fossil fuels technologies. The Administration course of action is a step backward for the nation's technical preparedness for coping with more demanding fossil resource recovery, more efficient fossil fuel utilization and more stringent environmental standards.

The Administration must recognize that the federal government has multiple roles in fossil energy development and that there is an urgent need for federal fossil R and D programs. Moreover, the coal industry does not possess the technology or the know-how to undertake long-term R and D programs. The result of a reduced governmental effort is that innovation and productivity in the coal industry suffer and we will make slower progress on substitution, coal for oil and gas in the utility and industrial sector. As oil prices drop in the short-run, private corporations show progressively less interest in making R and D investments in synthetic fuels from either coal or shale although we surely need to develop this technology today. In sum, the Administration performance in fossil energy is appalling. It sentences U.S. industry and the U.S. consumer to be more vulnerable to oil and gas supply interruptions and to pay more for energy in the long-run that would otherwise be necessary.

The following table summarizes my recommendations for addition to the Administration FY83 budget request for fossil energy.

Millions $ BA	FY82	FY83 Administration	Recommended Addition
Coal R & D			
Mining	11	1	10
Liquefaction	228	26	300
Surface gasification	53	10	150
Undergd. gasification	8	1	15
Adv. Res. & Tech.	56	20	50
Env. Control/prep.	25	9	20
Heat engines	15	-	10
Combustion Sys.	41	7	40
Fuel Cells	35	10	10
MHD	28	-	20
Subtotal	500	84	625
Oil R & D			
EOR	15	5	10
Shale	18	6	40
Gas R & D			
Unconventional Gas	12	-	15
Total Fossil Energy	551	95	690

Renewable Energy and Conservation Technology

The Administration's record in solar, other renewable energy and conservation technology is as poor as the record just described in fossil energy. The FY82 Carter budget submission contained approximately $1b for renewable energy and conservation R and D. The present Reagan FY83 budget submission request $101M, down from $518M in FY82.

The justification for these reductions is the Administration philosophy of reliance on the private sector for renewable technology development and exclusively on response to price for the stimulation of conservation technology. It is not necessary to repeat my view that the private sector will not respond, this is especially true for renewable energy R and D where one is attempting to develop new technology for the very long-term. Such an R and D effort is needed to assist this nation and the globe to make the transition more easily to a post-petroleum world. Today we should have in place a sustained, comprehensive, and aggressive R and D program that is not continually buffeted by rhetoric or budgetary spasms.

Conservation technology is of near term importance to this country. More efficient energy utilization no only lowers the cost to meet our energy needs but also decreases our dependence on imported oil. The value of reducing on consumption of fossil fuels is greater than the market price because of the security implications and future uncertainty in oil availability. Thus, in principle, the federal government has a role in conservation technology and in other conservation measures beyond the market place. And there are even more compelling practical reasons for federal action. First, in many instances consumers and industry are not sufficiently well informed about what is available in more energy efficient technology. Second, a long history of falling real energy prices has not encouraged the development of firms specializing in energy productivity. Third, both business and the consumer are confronted with high interest rates and low economic growth that encourages delay in conservation investments that might be cost/effective on a life-cycle basis. The inability of this nation, in both the public and private sector, to create new programs for the development of technology for more efficient energy utilization is one of the most evident failures of our energy R and D record since the Arab oil embargo of 1973.

The following Table summarizes my recommendations concerning renewable and conservation R and D in the FY83 budget.

Millions $ BA	FY82	FY83 Administration	Recommended Addition
Renewable Energy			
Solar Heating/Cooling	12	-	15
Solar Passive	11	-	15
Photovoltaic	74	27	75
Solar thermal	53	18	10
Biomars	21	7	15
Wind	34	5	35
OTEC	19	-	-
Alcohol fuels	10	3	5
International	4	10	10
Solar Information	7	-	5
SERI	-	-	20
Geothermal	54	10	15
Hydropower	3	-	10
Subtotal	302	80	230
Energy Shortage	38	-	40
Electric Systems	21	-	20
Conservation Technology			
Buildings/Comm. Sys.	48	-	30
Industrial	30	-	30
Transportation	59	-	30
Multi-sector	8	17	-
Subtotal	145	17	90
Total	506	97	380

I welcome the new thrust and major increases proposed for multi-sector conservation technology R and D.

Nuclear Energy

The FY83 budget request includes three types of nuclear energy programs. These are 1) fission programs, 2) a proposed new "Nuclear Waste Disposal Fund" to be funanced by utility user fees of $300M in FY83, and 3) Uranium Enrichment activities. The funds requested for nuclear fission (which includes commercial nuclear waste management but not defense nuclear waste management) come to $1016M versus $1066M in FY82. Nuclear energy has evidently been favored by this Administration over competing technologies. Moreover, for nuclear technology the rhetoric of the reliance on the market place is abandoned in order to pursue the unneeded and technically obsolete Clinch River Breeder Reactor (CRBR) project.

Here is not the place to discuss the grave limitations of the Administration's policies and programs for nuclear energy. Permit me to say that in place of a policy that appears to emphasize commercial reprocessing, the CRBR, and early breeder commercialization, I would adopt different priorities. These are: 1) thermal reactor technology R and D including reactor safety and reliability, improved LWR Uranium efficiency and HTGR R and D, 2) commercial waste management including a government run AFR for spent fuel (financed by a one-time user charge) and a large remedial reaction program that encompasse reasonable provisions for both West-Valley and TMI-2 clean-up, and 3) an aggressive breeder R and D program at a level of approximately $450M but termination of the CRBR project. These priorities are reflected in the recommended changes in the FY83 nuclear fission budget included in the table below.

Millions $ BA	FY82	FY83 Administration	Recommended Charge
Comm. Waste/Fund	210	265	-
Advanced Nuc. Sys.	38	31	-
Converter Reactor	96	32	100
Nuclear Fuel Cycle	53	59	-
Breeder Reactor Systems	647	577	-125(1)
Remedial Action	43	50	25
Total	1087	1014	-0-

(1) Termination of CRBR

In addition I would recommend a reorientation in the enrichment program. The world-wide slow down in nuclear energy signals a greatly reduced need for enrichment capacity. At the same time there has been substantial progress in advanced isotope separation (AIS) technologies, both in atomic and molecular laser separation methods and in the plasma separation method. The enormous potential, in cost savings, of these new methods compared to the conventional diffusion or centrifugation separation technology leads me to the conclusion that one should slow down construction of Centrifuge Enrichment Plan (GCEP) and accelerate the AIS program.

Unfortunately, the Administration program reduces support for AIS from $86M in FY82 to $34M in FY83. This reduction is based on selection of a single process from among the three competing methods. Such process selection may be premature in FY83 and in, any event, a sensible strategy would eliminate only one of the competing methods and proceed with two methods to the next stage of development. Such a strategy is especially sensible given the potential enormous cost savings of AIS and the possible application of these AIS techniques to Special Isotope Separation. In summary, I would recommend addition of $100M to the AIS program above the FY83 Administration budget request. This amount would permit pursuit of two development modules rather than one and a more extensive tech base program.

Concluding Remarks

Permit me to emphasize three main points. First, the private sector cannot be expected to undertake all needed energy R and D. A policy based on this assumption places our technical future in energy technology at risk. Second, the proposed DOE reorganization is misguided, it will not save money or improve R and D. Finally, I have provided a fairly comprehensive set of budget recommendations to give this Committee an impression of the level and distribution of the additional resources that I believe are required for this nation's energy technology effort. The specific amounts recommended for any individual program is of less importance than the overall picture I hope to convey -- significant additional resources are needed for energy R and D in the FY83 budget.

Senator GLENN. Now we will hear from Dr. Carl Sagan, director of the Laboratory for Planetary Studies at Cornell University.

We welcome you here this morning and we look forward to hearing your views on the matters we have been discussing. You have heard a lot of our concerns here this morning and we look forward to your comments.

TESTIMONY OF CARL SAGAN, SPACE SCIENCES DEPARTMENT, CORNELL UNIVERSITY

Mr. SAGAN. Thank you very much, Senator Glenn. I am very pleased to be here.

I thought I would direct my remarks primarily at the issue of planetary exploration which you referred to several times, and at the end say something about the general issue of science education about which I am very concerned.

The United States has performed over the last two decades a remarkable and historic series of explorations of the planets and their satellites. Just 20 years ago the first successful spacecraft launched by the human species to any other planet was launched and arrived at Venus. It was called Mariner 2, and it ushered in an epoch of closeup, flyby, orbitor, and lander exploration of the atmospheres, surfaces, and interiors of our neighboring worlds.

The historic significance of this is hard to overemphasize. There is only one moment in the history of the human species when for the first time we look at closeup and with some scientific rigor our neighboring worlds. The last 20 years has been that moment. I think this age will be remembered for those voyages of exploration when many of the issues which dominate our front pages will be delegated to the dustbin, or at least the footnotes, of history.

We have examined every planet which you can see with the naked eye, every one of those slowing moving points of light that our ancestors first called wanderers, and which in fact led to the development of science. This activity has become part of the popular culture. It has excited many people—not just youngsters, but certainly including youngsters—to a passion for science which has spilled over into other activities. Planetary science approaches some of the deepest questions that humans have ever asked—questions about the nature and origins of worlds, or the possibilities of life elsewhere—questions that are in some way or another treated by the creation myths of every culture, which in turn demonstrates the importance that humans attach to such questions.

There have been and continue to be practical advantages. I tend to be critical of spinoff arguments—the idea, for example, that the Apollo program is justified because a free stickless frying pan came out of it, when it is very clear that if your intent was to get a stickless frying pan you could have gotten one directly for a whole lot less money; nevertheless, some of the spinoffs from this sort of exploration have been impressive—in areas such as autonomous robotic systems computers, and spacecraft navigation. The development of complex robotic systems which are able to repair their own faults is very clearly a technology that has promising applications to many parts of the national and global economy.

In addition, by exploring other planets we much better understand our own. Dr. Deutch, for example, just mentioned the very serious question about the enhanced carbon dioxide greenhouse effect which comes from the burning of fossil fuel, particularly coal. Well, one of the areas which has most accelerated our understanding of the greenhouse effect in the Earth's atmosphere is the study of the atmosphere of the planet Venus, where there is a massive carbon dioxide greenhouse effect which raises the surface temperature of that planet to an unpleasant 900° Farenheit. Although no one proposes too much burning of coal is what is happening on Venus, this is a demonstration that a planet very much like the Earth can have devastating consequences happen to it because of such a greenhouse effect.

And in general, by comparing the Earth with other planets, we better understand sciences such as meteorology, climatology, geology, and at least prebiological organic chemistry. Even if we do not find life elsewhere, the comparison of other planets with ours helps us to understand and calibrate life on this planet.

If you are interested in having a general understanding of a complex science, you are in deep trouble if you have only a single example to study. If you have several different examples and you have to explain all of them, you are in a much better situation to try to understand on some fundamental level what is going on.

For the earth sciences in general, if we only have the Earth to study, we are in just such a difficulty that I just mentioned. If we have some other planets to study and we have to understand all of them and the Earth at the same time, we have a much better prospect of developing firm, rigorous, and predictive sciences, which in turn will have a multitude of constructive applications down here on our planet.

Now, if we look at the rate at which spacecraft have been launched to the Moon, the planets, and the satellites of the planets, we find, in the decades of the 1960's and 1970's, an extremely healthy and vigorous American planetary program—in parallel, by the way, with a healthy and vigorous Soviet planetary program.

So, in the 1960's we have Mariner 2 which I mentioned, a set of successful Rangers, Mariner 4—the first spacecraft to successfully examine the planet Mars, five lunar orbiters, Mariners 5 through 7, the set of surveyor lunar spacecraft, and Apollos 7 through 12.

In the decade of the 1970's, there was Mariner 9 at Mars, Mariner 10 at Venus and Mercury, Apollos 14 through 17—all manned lunar landers, Pioneers 10 and 11—the first spacecraft to explore Jupiter and beyond, Vikings 1 and 2—the first spacecraft to successfully land on Mars, Voyagers 1 and 2—which provided the first detailed looks at the Jupiter and Saturn systems, and the Pioneer Venus spacecraft.

But, if we look at the decade of the 1980's, Senator Glenn, we have only one approved America planetary mission, the Galileo Jupiter orbiter and probe which has been repeatedly delayed and most recently had an additional 1½ years and a consequent $170 million added to its timetable and budget.

It is very clear that the United States is backing off from the enterprise of the planets and is doing it in a very dramatic fashion.

The United States was unable to muster an expedition to rendezvous with Halley's comet, which comes by once every 76 years. It will be by the Earth in 1986. No nation has ever before done a closeup exploration of a comet. It is now too late for the United States to undertake such a mission.

Fortunately for the human community, the European Space Agency will launch its first mission beyond the Earth to Halley's comet, Japan will launch its first mission beyond the Earth to Halley's comet, and a Soviet-French consortium will launch a very interesting triple mission which will first drop a balloon into the atmosphere of Venus and a lander on its surface and then will carry on to rendezvous with Halley's comet. There will be two spacecraft, called Vega, each separately assigned this triple mission. We, the human species, will therefore find out something about Halley's comet. But the United States has had a remarkable record of distinguished achievement in this area which other nations have not been able, at least so far, to match and I feel that there are some unique capabilities that this Nation had to contribute to such missions. It is a pity that we are not doing a Halley intercept flight.

To continue the national comparisons, the Soviet Union was, of course, the first to photograph the back side of the Moon, the first to land on the Moon and the first to land successfully on Venus which is a very tough environment. Just a few days ago they landed two more spacecraft on the surface of Venus and obtained the first color photography of the surface of that planet. But the U.S.S.R. has yet to muster a successful mission to Mars, where they have repeatedly failed, and it has never attempted missions further out in the solar system. Mercury, Jupiter, and Saturn have never been visited by Soviet spacecraft because of questions of the reliability of electronics, guidance, propulsion and navigation systems. In these areas the United States has an acknowledged global leadership.

Scientific exploration of the planets is a benign technology that is widely recognized as an area of American leadership, and even those in other countries who have second thoughts about many aspects of American policy recognize that the U.S. achievement in planetary exploration has been distinctly to the benefit of the human species. It has certainly redounded to the prestige of the United States.

Ironically, we are now in the situation of one mission in the entire decade of 1980's. In addition, there is a disastrous, and, in my opinion, deeply foolish set of cutbacks in the utilization of existing spacecraft and their data, which amounts to a kind of retrospective undoing of missions that have previously been launched.

Senator **Glenn**. Is this in the data analysis area?

Mr. **Sagan**. Not just data analysis, but also the total loss of functioning spacecraft.

With the present fiscal year 1983 budget, it appears that all of the following will happen, in order to save $40 million in areas of mission operations and research analysis: I mentioned Pioneers 10 and 11; they are the farthest vanguard of the human species, spacecraft that have journeyed far beyond the orbit of Saturn. One of them is flying in the so-called heliotail; the Sun, the planets and the interplanetary medium are moving through interstellar space, and as a result the solar wind is dragged in the direction opposite to the motion. One of those spacecraft is flying through that tail. Both spacecraft have at least some chance of still operating as they penetrate the heliopause, the boundary between the solar system and the interstellar medium. Pioneers 10 and 11 may become the first interstellar space ships launched by the human species. In addition, perturbations in their trajectories may yield information about one or more massive undiscovered objects in the outer solar system, for which there is already tantalizing evidence. But there are now plans to turn both spacecraft off. Not only that, they will be permanently turned off. You can't change your mind later; there is a question of reacquiring the Earth, which the spacecraft will be unable to do.

Senator GLENN. When is that to occur?

Mr. SAGAN. I believe January 1, 1983, is the absolute dropdead date.

In addition, the Pioneer Venus spacecraft, the first U.S. spacecraft to orbit the planet Venus, are in the midst of a very successful data taking mode, including in situ analysis of the atmosphere of Venus. Because of orbital decay, these spacecraft will go lower and lower, deeper and deeper in the atmosphere, and will be able to sample new regions of the Venus atmosphere. By no means has it done everything that could be done. It also will be turned off.

In addition, Viking data analysis is in jeopardy. Viking was an enormously successful mission—two orbiters, two landers—and one of the orbiters had an orbital change maneuver later in the mission which permitted spectacularly more detailed photographs which were acquired just a year or two ago. More than 1,000 such pictures have not yet been looked at, a number of pictures which is comparable to the total output of the Mariner 9 mission to Mars, but with much greater detail than in those pictures. These Viking orbiter pictures are in digital form right now, and with the present budget there will be no money to convert them to analog form so you will be able to look at the pictures and see what is in them. From what has been looked at, they are clearly the best pictures ever taken of Mars from orbit.

In addition, the proposed budget cut for fiscal 1983 will decimate the analysis of Jupiter and Saturn data from the Vogayer 1 and 2 spacecraft, which have been spectacularly successful. We will have to shut down the Lunar Curatorial Facility in Houston, which not only holds the national treasure of rocks from the moon, but also meteorites obtained from Antarctica and micrometeorites which many people think are fragments of comets captured by high-altitude aircraft. If the President's budget plans go through, actual samples of extraterrestrial objects will be made unavailable to the scientific community.

The budget cuts will also close the NASA infrared telescope in Hawaii, one of the major planetary astronomy facilities in the world. And, finally, it will end all NASA research support for hundreds of planetary scientists, technicians and students. I think it is fair to say that there is a crisis of morale among planetary scientists at the present time as they see a steady whittling away of the basis of their support. Scientists are generally not in this field for money or prestige or anything but the excitement of doing the work. But scientists, like everybody else, have to eat—and when the scientific teams are broken up, when the laboratories are demoralized and dissipated, it is very hard to get them back together again when the Government changes its mind, as I certainly hope it will in a few years.

Many of the program terminations that I have just indicated are irreversible; those that are reversible are reversible with an enormous effort of time and human resources. Everything I have just talked about costs $40 million.

Senator GLENN. Grand total?

Mr. SAGAN. Yes. It is very easy to make comparisons, but the increment which would be needed over the present planetary program to make a very vigorous one over the next 5, 7, 8 years, is something like the cost of refurbishing one obsolete 30-year-old battleship. Maybe such a refurbishing is a good idea, but it provides an interesting comparison. Or, the incremental cost of such a program is equivalent to the cost of one B–1 bomber. I understand there is a request for a fleet of 100 bombers. Now, if the United States could only get by with 99——

Senator GLENN. With 99, that will give you 5 times the 40 you are talking about.

Mr. SAGAN. Sure. I was talking about a much more vigorous program than the one we have now [$1 billion/5=an increment of $200 million per year].

To give another kind of comparison, let me present a few numbers in inflated dollars, with no correction for inflation, for the net change in some basic scientific programs between fiscal year 1980 and fiscal year 1983: NASA space science in general up 28 percent, but that is overtaken by inflation. In these inflated dollars, oceanography supported by NSF, up 28 percent; high energy physics, supported by the Department of Energy, up 94 percent; planetary science and exploration down 30 percent, and, of course, if you make the corrections for inflation, then there has been a still deeper cut.

So, we see the curious situation of a program of historic proportions in which the United States has been the acknowledged world leader, a program which has enormous global impact on how people think about their society and themselves, which provides defensible technological spinoffs, which helps greatly in middle-term to understand and improve our own planet by comparing it with other planets—such a program being cut by an enormous factor at just the moment of its greatest triumphs.

There are many other areas of fundamental and applied science which are suffering in this way or which will suffer soon.

I would like, finally, Mr. Chairman, to turn to the issue of science education. Here is an area which is immensely critical. We live in a very complicated national and global society. Many problems are facing us. Some of them have long time-scales, some of them have shorter time-scales. We know we are going to have to face difficult scientific and technical problems in the next few decades.

It is also very clear that there are other science and technology problems that we are going to have to face that we are not now wise enough to be able to predict. If I look, for example, at the accidental way that the ozonosphere/halocarbon problem was stumbled upon, I begin to get the idea that there are many other serious problems that we have not been lucky enough to stumble on yet; we will stumble on them when the time available for correcting them will be very short.

The one sure way of guaranteeing that we can do our best at correcting those problems is to have a base of scientists and technologists of the highest quality who are able to move into new problems. To do that, it is vital to have first-rate science education—not just for those who are going to be scientists, but for the general community at-large, because public attitudes determine to a significant extent, how young people are motivated to go into science and technology.

If there is a general sense of science as an area dominated by the military and not generally supported by the Federal Government, then the brightest youngsters will go into other fields. There is beginning to be a trend in that direction.

Now, particularly in mathematics and physics, there has been a long tradition of the most fundamental discoveries being made by very young practitioners. In some areas of mathematics and theoretical physics, it is commonplace for people to be over the hill at 30 or 35. That means, in terms of their most creative research, a generation in those areas is something like 5 or 10 years. You can lose a whole generation of scientists by not supporting science education for, let's say, two Presidential terms of office—to pick a convenient unit of time.

If we look at the President's National Science Foundation budget, we find that support for graduate students in the sciences is, in inflated dollars, about the same as it has been for the last year or two, but virtually every other area of support for science education has been eliminated altogether—for example, training of high school science teachers, who are absolutely critical in determining career choices and providing adequate elementary education for future scientists. Here again, we are talking about small amounts of money, some millions of dollars, and large potential benefits that are in deep jeopardy.

In addition, cuts in other areas, for example, in support of public television, will have the certain result that science programing on television, which is the science medium that reaches the most people, will be cut. I am concerned that that involves a serious future loss in the new generation of scientists.

In short, I am afraid that we are in the position of eating the seedcorn. It is an analogy I have used for some years. It seems especially appropriate now. We are in the position of having a tough winter. We have stored some seeds of corn to plant next year. We know we can get through this winter if we eat the seedcorn, but then we will be in desperate straits the next winter since we will not have planted the crop for our future survival.

The present administration is pursuing, as least as far as science policy goes, extremely short-term objectives when there are demonstrable middle- and long-term objectives which will be severely compromised if these cuts continue.

Thank you.

Senator GLENN. Thank you. That is an excellent statement and I appreciate it very much. And your figures there, what comes under that $40 million title, are extremely impressive.

Some additional figures here, that are in the statement that I had back there on the table, from my Senate speech of March 8, 1982, on the subject of education should be emphasized. I will read from this:

> Last year American colleges and universities granted 58,000 degrees in engineering. By contrast, Japan, with roughly half our population, graduated 74,000, and the Soviet Union graduated about 300,000 engineers. In the field of computer science there is an estimated demand for 45,000 graduates at the bachelor's level, but we are only supplying 13,000 graduates. The estimated demand at the master's level is for 34,000 people, we are only graduating 3,400, and at the doctoral level the estimated demand is 1,300, whereas last year we only graduated 330.
>
> The intense demand for technically trained people has resulted in high salaries that are luring faculty and graduate students away from even our best universities. The result is unfilled faculty positions in our Nation's engineering colleges, and

a dramatic drop in the number of science and engineering students who are going on for advanced degrees. In 1979 for example, a full 46 percent of U.S. doctoral degrees in engineering went to foreign students—two-thirds of whom were studying here on temporary visas.

Senator GLENN. It is dismal.

Mr. SAGAN. Those foreign students know where the good science education is. The problem is that American students are not being encouraged to acquire the same education.

Senator GLENN. Even scientific students and faculties still have to eat.

People continually ask in these areas of planetary research: But of what possible good is it? That is diffcult to respond to in terms that people understand, as I am sure you are aware, and you have done such a tremendous job in your TV series and programs and trying to get across some of that concept to people. The one I have used is the fact that back when we first started some of the first space probes before man ever went into space we discovered the Van Allen belts. They thought: So what, so there are radiation belts up above the Earth. What difference does it make? Well, it was curiosity and then we find at times of solar activity there is a lower belt up and down that changes the heating of the upper atmosphere and it controls jet streams that controls our weather here on Earth. You begin to pick up an interrelationship. It is serendipity. We can't control weather here on Earth, and I am not sure we may want to, when you may end up with a lot of rain down in Colorado and make Western Europe into a desert if we are not careful how we manipulate it. But this knowledge tends to form a pattern and other facts are added to it. It then becomes useful sometime in the future.

That is the whole nature of scientific inquiry, whether macro or micro. You can't set out and say, this research will be valuable, that research will not be valuable. You are searching for the unknown and who knows what the value of that is? That is the nature of research and that is the reason I have supported the programs which you correctly point out need support.

Mr. SAGAN. You see, if you thought that our planet was hermetically sealed, closed off from the rest of the universe, then the reasons for exploring the rest of the universe might seem a little obscure. But once we realize that for example we are connected up with the rest of the universe, that what happens on the Sun has the most vital and practical consequences for agriculture or radio propagation here on the Earth, we begin to get some sense that those are not abstract studies to excite a handful of scientistes in white lab coats, but studies with very practical advantages for everyday matters down on Earth.

The retreat from fundamental science that the Reagan administration seems intent on fostering is happening at a time when there is enormous public interest in fundamental science—which you can see from the popularity of a half dozen new monthly magazines devoted to science and the appearance of serious books on science on the New York Times and other best seller lists, the popularity of "Nova" and other television programs devoted to science, and from public opinion polls.

It is very clear that people feel an unsatisfied curiosity about science. They understand it is powerful, they understand it will control their future, they also understand it is fun to understand the world. At just that moment when we have a real opportunity of communicating science to the population at large we find massive cutbacks being contemplated and implemented.

Senator GLENN. Knowledge is power. That is what will control our future. How much we know or don't know in competition with other people, that is how we will maintain our leadership and that is just as true in the planetary programs as it is in productivity programs here on Earth and I couldn't agree more that I just think it is tragic that we are in fact cutting back in these particular areas.

We are way over our time here this morning and I appreciate very much your comments.

I was extremely concerned until I heard your statement on TV this morning that we were about to have the potential end of the world tomorrow as we aline the planets on one side of the Earth. But, after hearing your statement this morning on television, which was quoted on one of the programs, I gather you don't feel that this congregation of the planets on one side of the Earth is going to give us any problem tomorrow.

Mr. SAGAN. To the best of my knowledge, I made no statement on television this morning.

Senator GLENN. They were quoting you.

Mr. SAGAN. That sometimes happens, spontaneous quotations which I had nothing to do with.

But, the situation is this: the planets are not "lining up" in a straight line, but in some vast sectors of more than 90°. At previous times when they have so lined up it was an extremely boring month. What is more, the tidal gravitational data forces are weak, and there is no plausible mechanism to produce any noticeable consequences here on Earth. The people who wrote the best selling book on "The Jupiter Effect," and claimed there would be resulting catastrophes have now concluded that it was a mistake. They chalked it up to youthful enthusiam. But if the world ends tomorrow, I will be very embarrassed.

Senator GLENN. You had better hope we don't have a giant earthquake here in the District of Columbia.

Mr. SAGAN. It will set science back even more than the Reagan budget.

Senator GLENN. Thank you.

We appreciate your being here.

The hearing will adjourn subject to the call of the Chair.

[Whereupon, at 12:20 p.m., the subcommittee recessed, to reconvene subject to the call of the Chair.]

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